NEC Scenario Analysis Report Nr. 1

Baseline scenarios for the revision of the NEC Emission Ceilings Directive

Part 1: Emission projections

Corrected version, September 21, 2006

Background document for the
Conference on
Air Pollution and Greenhouse Gas
Emission Projections for 2020

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Introductory note:

This report provides a preview on the NEC baseline projections of air pollutant emissions as a basis for the discussions at the Conference on Air Pollution and Greenhouse Gas Emission Projections for 2020, Brussels, September 29, 2006. Detailed information on emission projections for individual countries and sectors will be made available on the Internet (www.iiasa.ac.at/web-apps/apd/RainsWeb/index.html) before the Conference.

Part 2 of the report with information on health and environmental impacts will be made available in due time before the Conference.

Glossary of terms used in this report

CAFE	Clean Air For Europe Programme
CAP	Common Agricultural Policy
CAPRI	Agricultural model developed by the University of Bonn
CH_4	Methane
CLE	Current legislation
CO_2	Carbon dioxide
EEA	European Environment Agency
EFMA	European Fertilizer Manufacturer Association
EMEP	European Monitoring and Evaluation Programme
EU	European Union
GW	Gigawatt
IIASA	International Institute for Applied Systems Analysis
IPPC	Integrated Pollution Prevention and Control
kt	kilotons = 10^3 tons
Mt	megatons = 10^6 tons
N_2O	Nitrous oxides
NEC	National Emission Ceilings
NH_3	Ammonia
NO_x	Nitrogen oxides
O_3	Ozone
PJ	petajoule = 10^{15} joule
PM10	Fine particles with an aerodynamic diameter of less than 10 µm
PM2.5	Fine particles with an aerodynamic diameter of less than 2.5 µm
PRIMES	Energy Systems Model of the National Technical University of Athens
RAINS	Regional Air Pollution Information and Simulation model
SNAP	Sector aggregation system of the CORINAIR emission inventory
SO_2	Sulphur dioxide
SOMO35	Sum of excess of daily maximum 8-h means over the cut-off of 35 ppb
calculated	
	for all days in a year
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
WHO	World Health Organisation

Table of contents

1 Introduction

In its Thematic Strategy on Air Pollution, the European Commission outlined the strategic approach towards cleaner air in Europe (CEC, 2005). As one of the main policy instruments, the Thematic Strategy announced the revision of the Directive on National Emission Ceilings (2001/81/EC) with new emission ceilings based on the agreed interim objectives up to 2020.

To establish a shared knowledge base for the Thematic Strategy, the European Commission and stakeholders have explored in the Clean Air For Europe (CAFE) programme the necessity, scope and cost-effectiveness of further action to achieve the long-term environmental policy objectives for air quality of the European Union. This analysis brought together information on the sources of emissions, on their likely development in the future, on the technical options to reduce air pollutant emissions and their costs, on the dispersion of pollutants in the atmosphere and their impacts on human health and ecosystems. The CAFE programme explored for a range of environmental ambition levels cost-effective pollution control strategies, and thereby provided the Commission and the other policy institutions with quantitative information for the policy decision on the Thematic Strategy. For this analysis the CAFE programme employed the RAINS (Regional Air Pollution Information and Simulation) integrated assessment model. RAINS holds for all European countries databases with the essential information on the relevant aspects and links this data in such a way that the environmental implications of alternative assumptions on economic development and emission control strategies can be assessed.

As a follow-up to the CAFE programme, the European Commission started a process to develop national ceilings for the emissions of the relevant air pollutants that should lead to the achievement of the environmental interim objectives of the Thematic Strategy. An extended version of the RAINS model called GAINS that allows the analysis of interactions between air pollution control and greenhouse gas mitigation will be used as the central analytical tool for this analysis. It is planned that the development of the national emission ceilings follows a step-wise approach. The analysis will start from an updated baseline projection of emissions and air quality impacts as it can be expected from the envisaged evolution of anthropogenic activities taking into account the impacts of the presently decided legislation on emission controls. A second step will then identify sets of cost-effective measures that achieve the environmental ambition levels of the Thematic Strategy and examine their distributional implications on costs and benefits to the various Member States and economic sectors. The third step will then assess the robustness of the identified emission ceilings against a range of uncertainties.

This report presents the results of the updated baseline assessment. The analysis combines recent information on expected trends in energy consumption, transport, industrial and agricultural activities with validated databases describing the present structure and technical features of the various emissions sources in all 25 Member States of the European Union, the four accession candidate countries as well as Norway and Switzerland. It considers the penetration of already decided emission control legislation in the various Member States in the coming years and thereby outlines a likely range for the future emissions of air pollutants up to 2020. In Part 2 of this report, the analysis sketches the resulting evolution of air quality in Europe and quantifies the consequences on the effects of air pollution on human health and vegetation using a range of indicators.

This report presents the key findings of the analysis conducted for the baseline projection under contract with the European Commission. While all calculations are carried out at a national and sectoral level, this report restricts itself to the presentation of aggregated results. The interested reader is invited to explore detailed results with the Internet version of the RAINS model, which can be freely accessed at www.iiasa.ac.at/web-apps/apd/RainsWeb/index.html.

The remainder of the report is organized as follows: Section 2 provides a brief introduction of the concept and modelling tool that have been used for the development of the NEC baseline scenario and summarizes the validation process of the model databases with experts from Member States and Industry. Input assumptions on the driving forces for emissions, i.e., various projections of future energy use and agricultural activities, are presented in Section 3. Chapter 4 presents the resulting estimates of baseline emissions for the EU Member States, the accession candidate countries, and Norway and Switzerland.

2 Methodology

2.1 The RAINS and GAINS models

The integrated assessment conducted for the CAFE programme applied as a methodological tool the RAINS model, which describes the pathways of pollution from anthropogenic driving forces to various environmental impacts. In doing so, the model holds for all European countries databases with the essential information on all aspects listed above and links this data in such a way that the environmental implications of alternative assumptions on economic development and emission control strategies can be assessed.

The RAINS model, developed at the International Institute for Applied Systems Analysis (IIASA), combines information on economic and energy development, emission control potentials and costs, atmospheric dispersion and environmental sensitivities towards air pollution (Schöpp *et al.*, 1999). The model addresses the threats to human health posed by fine particulates and ground-level ozone as well as risk of ecosystems damage from acidification, excess nitrogen deposition (eutrophication) and exposure to elevated ambient levels of ozone. These air pollution-related problems are considered in a multi-pollutant context, quantifying the contributions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compounds (VOC), and primary emissions of fine (PM2.5) and coarse (PM2.5-PM10) particles (Table 2.1).

Table 2.1: The multi-pollutant/multi-effect approach of the RAINS model

	Primary PM	SO_2	NO_x	VOC	NH_3
Health impacts:					
- PM	√	√	√		√
- O_3			√	√	
Ecosystems impacts:					
- O_3			√	√	
- Acidification		√	√		√
- Eutrophication			√		√

Recently, the RAINS model has been extended to capture (economic) interactions between the control of conventional air pollutants and greenhouse gases. This GAINS (Greenhouse gas – Air pollution Interactions and Synergies) model includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), the F-gases (Klaassen *et al.*, 2004). Thereby, the traditional RAINS model constitutes the air pollution-related part of the GAINS model, while the GAINS extensions address the interactions between air pollutants and greenhouse gases. The baseline projection for the revision of the NEC directive relies for the air pollutants SO_2, NOx, VOC, NH_3 and PM2.5 on the traditional RAINS model, while the projections for CO_2 have been developed with the recent GAINS extensions.

A detailed description of the RAINS model is provided in Amann *et al.*, 2004b. On-line access to the RAINS and GAINS model and to all input data is available at http://www.iiasa.ac.at/rains.

As a basic feature, integrated assessment models attempt to gain comprehensive insights into the full range of issues related to the strategies under consideration by including as many aspects as possible. However, it is also crucial to keep integrated assessment models manageable and transparent in order to facilitate the direct interaction with decision makers in the analysis of a large number of alternatives in a timely manner. Thus, it is the art of integrated assessment modelling to strike the right balance between a wide coverage on the one hand and practical manageability (for modellers) and transparency (for users) on the other.

Over time, the RAINS model has incorporated a large number of aspects of air pollution, and can now provide policy-relevant insight into many facets of air pollution control. However, deliberate decisions were taken by the developers of RAINS to keep certain aspects outside the model, partly because they are of less relevance than other aspects, and partly because an appropriate treatment of these issues would dramatically increase the complexity of the model and thus seriously compromise its performance and transparency.

Nevertheless, it is recognized that, while RAINS allows flexibility, many aspects that are presently not 'hard-wired' into RAINS are important, although they might have significant policy relevance. This applies particularly to the assessment of ancillary benefits, to the monetary evaluation of benefits. Emission control options that imply substantial structural changes in the economy (or deviations from the baseline assumptions about economic development) have been excluded from the RAINS analysis, but are now considered in the GAINS model.

2.2 Emission estimates

For each of the pollutants listed in Table 2.1, RAINS estimates emissions based on activity data, uncontrolled emission factors, the removal efficiency of emission control measures and the extent to which such measures are applied:

$$E_{i,p} = \sum_k \sum_m A_{i,k} ef_{i,k,m,p} x_{i,k,m,p} \qquad (1)$$

where:

i, k, m, p	Country, activity type, abatement measure, pollutant, respectively
$E_{i,p}$	Emissions of pollutant *p* (for SO_2, NO_x, VOC, NH_3, PM2.5) in country *i*
$A_{i,k}$	Activity level of type *k* (e.g., coal consumption in power plants) in country *i*
$ef_{i,k,m,p}$	Emission factor of pollutant *p* for activity *k* in country *i* after application of control measure *m*
$x_{i,k,m,p}$	Share of total activity of type *k* in country *i* to which a control measure *m* for pollutant *p* is applied. These variables reflect for each country, sector and time step the implementation of the "Current Legislation".

This approach allows capturing critical differences across economic sectors and countries that could justify differentiated emission reduction requirements in a cost-effective strategy. It reflects structural differences in emission sources through country-specific activity levels. It represents major differences in emission characteristics of specific sources and fuels through source-specific emission factors, which account for the degrees at which emission control measures are applied. More detail is available in Cofala and Syri, 1998a, Cofala and Syri, 1998b, Klimont *et al.*, 2000, Klimont *et al.*, 2002, and Klimont and Brink, 2004. RAINS estimates future emissions according to Equation 1 by varying the activity levels along exogenous projections of anthropogenic driving forces and by adjusting the implementation rates of emission control measures.

2.3 Bilateral consultations with the CAFE stakeholders

From March to November 2005, the databases of the RAINS model that describe the national situations in terms of driving forces, energy consumption, agricultural activities, emission source structures and emission control potentials have been reviewed by national experts. IIASA hosted a series of bilateral consultations with experts from Member States and industrial stakeholders to examine the draft RAINS databases and improve them to reflect to the maximum possible extent the country-specific conditions as seen by the various experts without compromising international consistency and comparability (Table 2.2).

Table 2.2: Dates of bilateral consultations between experts from Member States and industrial associations and IIASA

Country or industrial association	*Dates of bilateral consultations with IIASA*
Austria	26 September 2005
Belgium	15-16 September 2005
Czech Republic	20 June 2005
Denmark	6-7 September 2005
Estonia	2-3 November 2005
Finland	16-17 August 2005
France	18-19 October 2005
Germany	18-19 July 2005
Hungary	30-31 May 2005
Ireland	11-12 October 2005
Italy	27-28 June 2005
Latvia	8-9 November 2005
Malta	23 November 2005
Norway	10-11 November 2005
Poland	1-2 September 2005
Portugal	7-8 July 2005
Slovakia	12 July 2005
Slovenia	15-16 November 2005
Spain	15-16 June 2005
Sweden	21-22 September 2005
Netherlands	6-7 October 2005
UK	23-24 August 2005
Adhesives industry	22 March 2005
Printing industry	21 March 2005
EURELECTRIC	27 April 2005
ECCA (coil coating)	05 July 2005
CEPE (coatings)	23 September 2005

This series of the bilateral consultations for the revision of the NEC Directive followed the earlier consultations that prepared the model input for the analyses of the CAFE programme (Amann *et al.*, 2004a). At these meetings, discussions addressed the input of national activity projections for energy, agriculture, non-energy sources of VOC and other industrial processes not related to energy consumption. They improved the representation of the national base year emission inventories in the RAINS model, and refined the descriptions of the temporal implementation patterns of national emission control legislation and the assessment of the potential for further emission reductions.

For agriculture, national projections and base year data were compared and discussed against statistical information available from international databases (FAO, EUROSTAT, IFA) and modelling results from CAPRI and the European Fertilizer Manufacturer Association. For specific VOC sources related to solvent use, a number of meetings with several industrial associations were held. Industry provided sectoral information on activities, emission factors and their potential future developments.

The minutes of these consultations have been made available to the stakeholders to aid the understanding of the construction of the baseline scenario. The discussions at these bilateral meetings were followed up by intensive electronic data exchange until September 2006.

These consultations generated a wealth of well-documented new information, which helped to revise the RAINS databases so that national emission inventories can now be better reproduced while maintaining international consistency and comparability of the assessment. However, a number of discrepancies between national data and the Europe-wide RAINS estimates could not be clarified to a satisfactory extent:

- For some countries, emissions reported in their national emission inventories are still burdened with high uncertainties. This applies in particular to earlier estimates that have not been not updated with more recent information. The RAINS estimates attempt to match the most recent estimates that have been communicated by national experts during the consultations, even if they have not yet been provided to EMEP through the official channels.
- While in most cases there is a good match between national inventories and RAINS estimates achieved for national total emissions, certain discrepancies occur between the estimates of sectoral emissions. Often this is caused by different sectoral groupings applied in national emission inventories, while the RAINS model applies a common sectoral structure for all countries. For instance, the RAINS model includes industrial power production and district heating plants in the power generation sector, while some national systems use the ownership of the plant as aggregation criterion. In addition, the definition of industrial process emissions is often a source of potential differences at least at the sectoral level (RAINS “process emissions” account only for the additional emissions that add to the fuel-related emissions).
- The UNECE nomenclature for reporting (NFR), while establishing consistency with the UNFCCC reporting format for greenhouse gases, bears certain ambiguity on details of air pollutants (e.g., on non-road mobile sources in industry and construction, and on emissions from industrial processes).
- For many countries it was found difficult to establish consistency of data on fuel use, vehicle-km and vehicle numbers. In particular, projections of future mileage and registration data have only been received from a few countries. While this issue is of less concern for the emission calculation, it will become crucial for an accurate assessment of emission control costs.

- While the RAINS model consistently applies the “fuel sold” concept for computing emissions, some countries (e.g., Luxembourg) calculate their national emissions based on the “fuel used” concept.
- For a number of countries there still exist significant discrepancies between national and international statistics for animal numbers and fertilizer use.
- Only scarce information is available on animal housing types. The projection of their development is even more difficult, but of high relevance for estimating potential and costs of further emission reductions.
- The availability of information necessary to estimate accurately emissions of VOC from solvent use varies significantly among countries. This causes potential inconsistencies across countries and industrial sectors.
- The new emission reporting system to the UNECE that follows CRF does not allow a detailed analysis of VOC inventories, since up to 70 percent of the emissions are grouped into only four large categories. Some further detail, however, is vital for estimating the further potential for emission reductions.

3 Input data

3.1 Energy projections

As a starting point for the further analysis, Table 3.1 summarizes the statistics on energy consumption by fuel for the year 2000 as implemented in the RAINS database. As these are historic data, both the national and PRIMES projections will be compared against the same basis.

Table 3.1: Primary energy consumption in 2000 [PJ]. Source: RAINS (based on EUROSTAT energy balances)

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import*[1)]	*Total*
Austria	119	128	114	253	114	324	0	153	-5	1200
Belgium	257	49	78	497	447	655	496	2	15	2496
Cyprus	1	0	47	22	25	1	0	1	0	99
Czech Rep.	823	28	58	147	112	385	147	6	-38	1668
Denmark	165	70	72	152	125	205	0	19	2	811
Estonia	102	21	10	16	14	31	0	0	-4	190
Finland	207	237	80	171	118	189	236	47	39	1325
France	494	448	452	1811	1351	1727	4538	259	-250	10830
Germany	3327	221	741	2469	2252	3334	1851	117	-46	14265
Greece	382	40	170	279	223	96	0	19	0	1208
Hungary	156	16	94	87	107	423	153	1	12	1049
Ireland	117	7	70	160	97	144	0	4	0	599
Italy	426	139	1262	1213	1335	2445	0	339	150	7309
Latvia	3	49	9	19	16	41	0	10	16	164
Lithuania	4	26	37	24	26	96	91	1	-5	301
Luxembourg	5	2	1	55	40	28	0	1	21	152
Malta	0	0	19	6	9	0	0	0	-1	34
Netherlands	269	60	112	504	569	1542	39	4	68	3167
Poland	2279	166	210	320	296	557	0	8	-23	3812
Portugal	155	133	247	220	175	97	0	46	3	1076
Slovakia	136	47	22	33	28	315	178	17	-10	766
Slovenia	57	17	6	51	39	35	52	15	-11	263
Spain	830	155	610	1027	853	800	672	125	16	5087
Sweden	95	294	131	237	263	57	619	286	-8	1975
UK	1771	58	176	1119	1735	3983	822	88	31	9782
EU-25	12179	2413	4827	10893	10370	17509	9894	1567	-26	69626
Bulgaria	270	23	52	59	63	136	196	10	-17	793
Croatia	30	22	99	56	42	121	24	16	11	421
Romania	279	116	171	137	98	635	59	53	-3	1545
Turkey	910	346	401	375	479	600	0	114	12	3236
Norway	56	49	9	151	147	245	0	515	-69	1104
Switzerland	6	23	36	264	247	110	289	137	-25	1087

[1)] Exports are indicated by negative numbers.

Table 3.2: Energy consumption of the EU-25 by fuel and sector in 2000 [PJ] Source: RAINS (based on PRIMES and EUROSTAT energy balances)

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import[1)]*	*Total*
Power sector	9248	437	1452	166	18	4425	9894	1531	-10214	16957
Industry	1535	789	1098	399	351	4855	0	4	3639	12670
Conversion	288	13	921	131	77	1208	0	0	1468	4107
Domestic	580	1173	113	2741	574	6391	0	33	4912	16517
Transport	0	0	70	7284	7535	17	0	0	169	15075
Non-energy	528	0	1173	173	1814	613	0	0	0	4300
Total	12179	2413	4827	10893	10370	17509	9894	1567	-26	69626

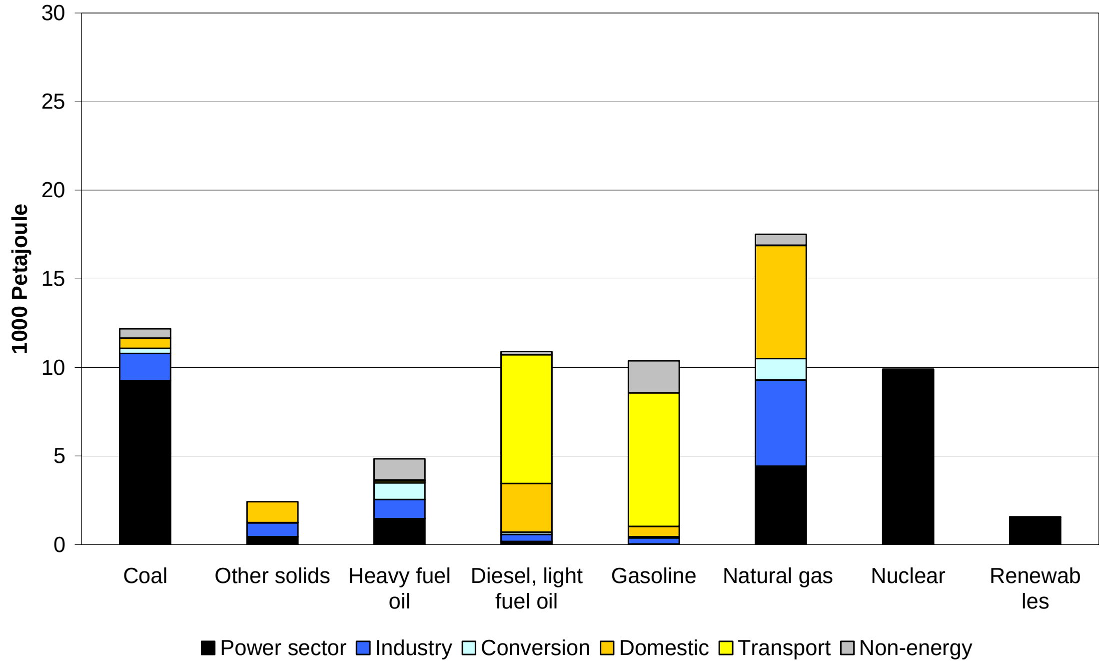

Figure 3.1: Energy consumption in 2000

3.1.1 National energy projections for 2020

For the revision of the NEC directive, DG-Environment of the European Commission has requested in 2005 all Member States to provide official national energy projections up to 2020 as a basis for the revision of the national emission ceilings directive. These projections must reflect national policies (as laid down, e.g., in governmental energy plans). Furthermore, these projections must include all necessary measures to comply with the Kyoto targets on greenhouse gas emissions and the burden sharing agreement for 2012. For 2020, it should be assumed as a minimum that the Kyoto emission caps remain unchanged. With these requirements, the national energy projections for the revision of the NEC Directive should be consistent with the energy projections presented by the Member States to UNFCCC in their Fourth National Communications in 2006.

In the course of the bilateral consultations in 2005-2006, 21 Member States have supplied national energy projections to IIASA for implementation into the RAINS model (Table 3.3).

Collectively, these national projections constitute the "National projections" baseline scenario for the revision of the NEC directive. For those Member States that have not provided their own energy projection, the "National projections" baseline case assumes by default the energy development as outlined by the "PRIMES €20" energy projection (see Section 3.1.2).

Table 3.3: Data sources for the "National projections" NEC baseline scenario

	Data source	*Date of last information exchange*
Austria	National projection (2006)	12 June 2006
Belgium	National projection (2006)	31 August 2006
Cyprus	PRIMES €20 (2006)	No national inputs
Czech Rep.	National projection (2006)	01 August 2006
Denmark	National projection (2006)	06 April 2006
Estonia	National projection (2006)	24 April 2006
Finland	National projection (2006)	22 June 2006
France	National projection (2006)	30 June 2006
Germany	National projection (2006)	05 May 2006
Greece	PRIMES €20 (2006)	No national inputs
Hungary	National projection (2006)	11 August 2005
Ireland	National projection (2006)	11 September 2006
Italy	National projection (2006)	07 July 2006
Latvia	National projection (2006)	09 December 2005
Lithuania	PRIMES €20 (2006)	No national inputs
Luxembourg	PRIMES €20 (2006)	No national inputs
Malta	National projection (2006)	05 September 2006
Netherlands	National projection (2006)	14 September 2006
Poland	National projection (2006)	01 December 2005
Portugal	National projection (2006)	28 June 2006
Slovakia	National projection (2006)	04 November 2005
Slovenia	National projection (2006)	01 June 2006
Spain	National projection (2006)	11 July 2006
Sweden	National projection (2006)	08 September 2006
UK	National projection (2006)	28 February 2006
Bulgaria	PRIMES €20 (2006)	
Croatia	RAINS projection from 1996	
Romania	PRIMES €20 (2006)	
Turkey	PRIMES €20 (2006)	
Norway	National projection (2006)	02 February 2006
Switzerland	National projection (2006)	14 July 2006

[1)] Exports are indicated by negative numbers.

The perceived evolution of fuel consumption in the various Member States is summarized for the year 2020 in Table 3.4. Overall, EU-25 Member States expect an increase in total primary energy use by 15 percent between 2000 and 2020. Coal consumption is projected to decrease by seven percent, while for natural gas a 44 percent increase is envisaged. Member States anticipate a seven percent drop in gasoline consumption and a 33 percent increase in diesel and light fuel oil. According to these projections, the EU-25 would turn from a net electricity exporter (26 PJ in 2000) into a net importer (30 PJ in 2020).

Table 3.4: Primary energy consumption of the national energy projections in 2020 [PJ] Source: RAINS, based on national submissions to IIASA.

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import*[1)]	*Total*
Austria	129	179	53	389	86	463	0	201	0	1500
Belgium	160	82	53	567	449	933	338	15	17	2614
Cyprus	1	3	68	26	33	1	0	4	0	135
Czech Rep.	718	84	87	184	180	467	318	17	-25	2031
Denmark	114	122	54	174	146	315	0	45	-8	962
Estonia	172	21	13	30	16	45	0	2	-9	289
Finland	180	336	74	173	118	288	345	56	21	1591
France	484	711	540	2464	1113	2185	5093	360	-139	12811
Germany	3550	306	510	2616	1492	4041	693	363	-70	13501
Greece	293	30	166	422	303	277	0	67	9	1568
Hungary	119	99	0	182	128	615	161	1	21	1325
Ireland	63	35	35	277	173	326	0	18	6	933
Italy	657	406	507	1501	1314	3410	0	483	304	8580
Latvia	47	60	24	50	40	72	0	16	17	324
Lithuania	1	44	20	48	37	205	45	5	-14	391
Luxembourg	1	5	2	71	47	59	0	1	23	209
Malta	0	1	21	14	13	0	0	0	0	50
Netherlands	402	154	146	830	762	1555	39	96	12	3997
Poland	2046	305	297	566	387	1121	0	50	-19	4753
Portugal	96	149	224	349	172	358	0	100	-108	1339
Slovakia	259	55	28	42	49	399	89	28	-8	943
Slovenia	47	29	4	86	24	70	59	21	-23	317
Spain	500	544	308	1556	804	3321	626	394	0	8054
Sweden	84	430	122	242	247	196	448	275	-11	2033
UK	1170	160	100	1605	1465	4495	268	406	35	9704
EU-25	11292	4350	3457	14465	9596	25216	8522	3026	30	79954
Bulgaria	139	48	47	112	134	214	215	19	-20	909
Croatia	31	17	80	68	55	187	25	21	4	487
Romania	392	182	125	319	214	988	125	89	-3	2430
Turkey	935	325	483	662	1128	1790	0	367	-10	5681
Norway	68	58	13	187	182	358	0	455	7	1328
Switzerland	7	35	36	291	198	125	308	155	-23	1132

[1)] Exports are indicated by negative numbers.

Overall, this set of energy projection would lead to a two percent increase in CO_2 emissions compared to the base year level of the Kyoto protocol. CO_2 emissions are discussed in detail in Section 4.1.

While these national projections are supposed to reflect the latest governmental views in the individual Member States on the future energy development, there is no guarantee for Europe-wide consistency in terms of assumptions on economic development trends, the prices of oil, gas, coal, etc., on electricity imports and exports, and on the availability of natural gas. Unfortunately, Member States did not supply sufficient detail to judge the EU-wide consistency of the underlying assumptions.

Table 3.5: Energy consumption of the EU-25 by fuel and sector for the national energy projections for 2020 [PJ]

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import*[1)]	*Total*
Power sector	8879	1690	510	131	12	8783	8522	2869	-13411	17985
Industry	1316	1335	844	503	292	5999	0	3	4652	14945
Conversion	235	137	870	347	118	1191	0	0	1603	4501
Domestic	375	1187	84	2576	447	7895	0	141	6975	19679
Transport	0	0	72	10742	7061	112	0	12	211	18210
Non-energy	488	0	1077	166	1666	1236	0	0	0	4633
Total	11292	4349	3457	14465	9596	25216	8522	3026	30	79954

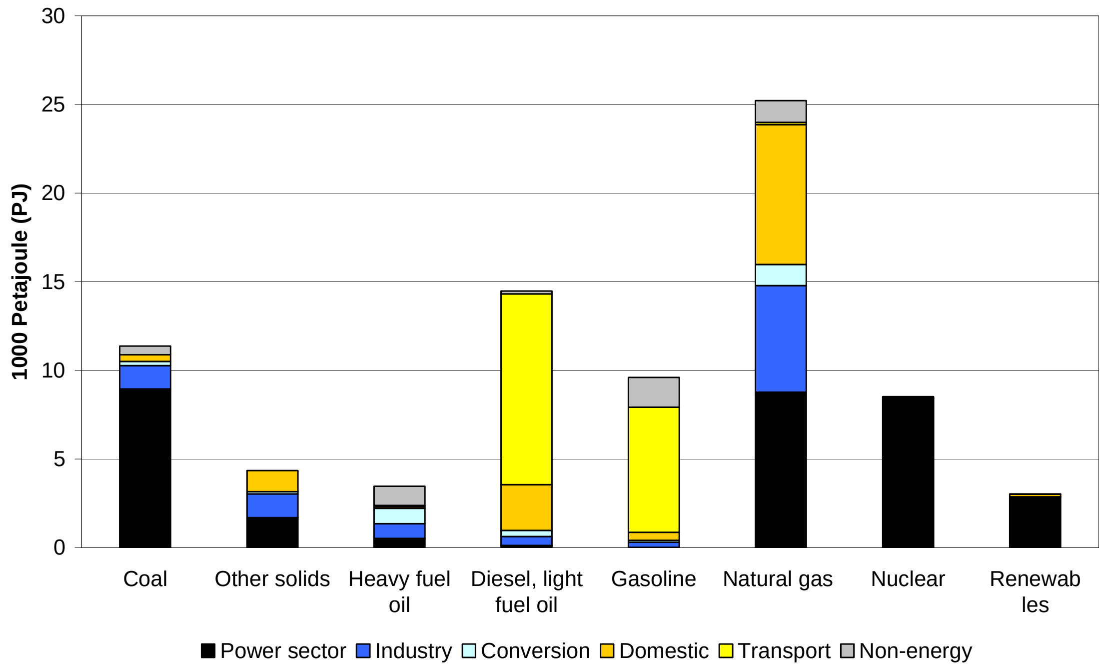

Figure 3.2: Energy consumption of the EU-25 as projected by the national scenarios for 2020

3.1.2 The PRIMES energy projection for a €20 carbon price

To explore the robustness of national emission estimates against alternative assumptions on the future development of the energy systems, an energy projection produced with the PRIMES model for all 25 EU Member States has been implemented into RAINS as a second baseline scenario. This projection follows the assumptions on macro-economic development adopted for the 2005 energy baseline projection of DG-TREN, with an increase of oil prices up to $50 by 2020.

Based on the guidance received from DG ENV's Climate Change unit, without prejudging the actual implementation of the Kyoto agreement and of possible post-Kyoto regimes, this scenario assumes for 2010 for all energy consumers a revenue-neutral "shadow price" of €12 per tonne of CO_2. It is thus implicitly assumed that any measures having a compliance cost higher than this will not be undertaken by the EU's energy system, but that other sectors (e.g., non-CO_2 greenhouse gases emitting sectors) would reduce their emissions, or that flexible instruments in the Kyoto Protocol would be used. In addition, the possibility of using carbon sinks would add to the flexibility. Concerning "post-Kyoto", it was assumed that the "shadow price" of carbon dioxide would increase linearly to €20 per tonne of CO_2 in 2020. For 2020, this assumption would lead to seven percent decline in CO_2 emissions of the EU-25 Member States compared to the baseline emissions of the Kyoto treaty.

Table 3.6: Primary energy consumption of the PRIMES €20 carbon prices scenario in 2020 [PJ]. Source: RAINS, based on PRIMES energy balances

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import*[1)]	*Total*
Austria	72	172	85	314	146	485	0	219	6	1500
Belgium	160	62	100	489	336	853	377	20	19	2415
Cyprus	1	3	68	26	33	1	0	4	0	135
Czech Rep.	469	86	76	188	195	572	342	11	-46	1892
Denmark	107	111	44	186	126	230	0	57	-12	848
Estonia	61	30	12	29	23	61	0	3	-1	217
Finland	114	380	85	217	142	264	375	68	14	1659
France	249	686	372	2160	1385	1872	5132	439	-178	12117
Germany	2022	768	411	2488	2296	4507	339	454	39	13324
Greece	293	30	166	422	303	277	0	67	9	1568
Hungary	90	85	58	132	148	636	150	7	10	1315
Ireland	25	26	46	217	166	249	0	27	4	760
Italy	705	250	1041	1274	1196	3348	0	446	135	8396
Latvia	4	75	16	31	26	111	0	14	8	286
Lithuania	1	44	20	48	37	205	45	5	-14	391
Luxembourg	1	5	2	71	47	59	0	1	23	209
Malta	0	1	23	8	13	0	0	0	0	46
Netherlands	277	143	126	351	606	1895	45	48	46	3539
Poland	1658	595	190	582	553	1162	173	66	-20	4961
Portugal	105	100	138	261	283	286	0	92	4	1269
Slovakia	124	57	54	49	72	435	205	26	-11	1011
Slovenia	40	23	11	56	55	76	58	18	6	342
Spain	183	432	572	1475	1171	1818	876	425	11	6963
Sweden	167	478	73	303	309	170	423	279	9	2211
UK	851	275	358	1099	1906	4119	1110	241	29	9987
EU-25	7780	4917	4148	12475	11573	23692	9649	3039	89	77363
Bulgaria	139	48	47	112	134	214	215	19	-20	909
Croatia	31	17	80	68	55	187	25	21	4	487
Romania	392	182	125	319	214	988	125	89	-3	2430
Turkey	935	325	483	662	1128	1790	0	367	-10	5681
Norway	16	71	30	186	144	223	0	556	-28	1199
Switzerland	7	131	29	234	248	210	299	167	-27	1297

[1)] Exports are indicated by negative numbers.

Larger fuel efficiency improvements than those assumed in the national energy projections would let total primary energy consumption grow between 2000 and 2020 by only 11 instead of 15 percent (Table 3.6). The larger degree of decarbonisation is reflected by a 36 percent reduction in coal consumption (compared to the seven percent decline in the national projections), while natural gas use would increase by only 35 percent compared to 44 percent as anticipated by Member States. Instead of a 33 percent increase in the consumption of middle distillates (diesel and light fuel oil, this scenario projects only a 15 percent increase. Gasoline use is suggested to grow by 12 percent (and not to shrink by seven percent). In total, the EU-25 would import even more electricity than in the national projections.

Table 3.7: Energy consumption by fuel and sector of the EU-25 for the PRIMES €20 energy projection for 2020 [PJ]

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import[1)]*	*Total*
PP	6150	2791	838	153	0	8388	9649	2897	-14261	16605
Industry	1328	378	1009	490	340	6156	0	0	4727	14428
Conversion	94	283	359	6	8	519	0	0	1766	3034
Domestic	147	1464	80	2743	447	7944	0	122	7594	20542
Transport	0	0	80	8893	8819	18	0	20	263	18094
Non-energy	61	0	1783	189	1958	667	0	0	0	4659
Total	7780	4917	4148	12475	11573	23692	9649	3039	89	77363

Data Source: RAINS, based on PRIMES energy balances

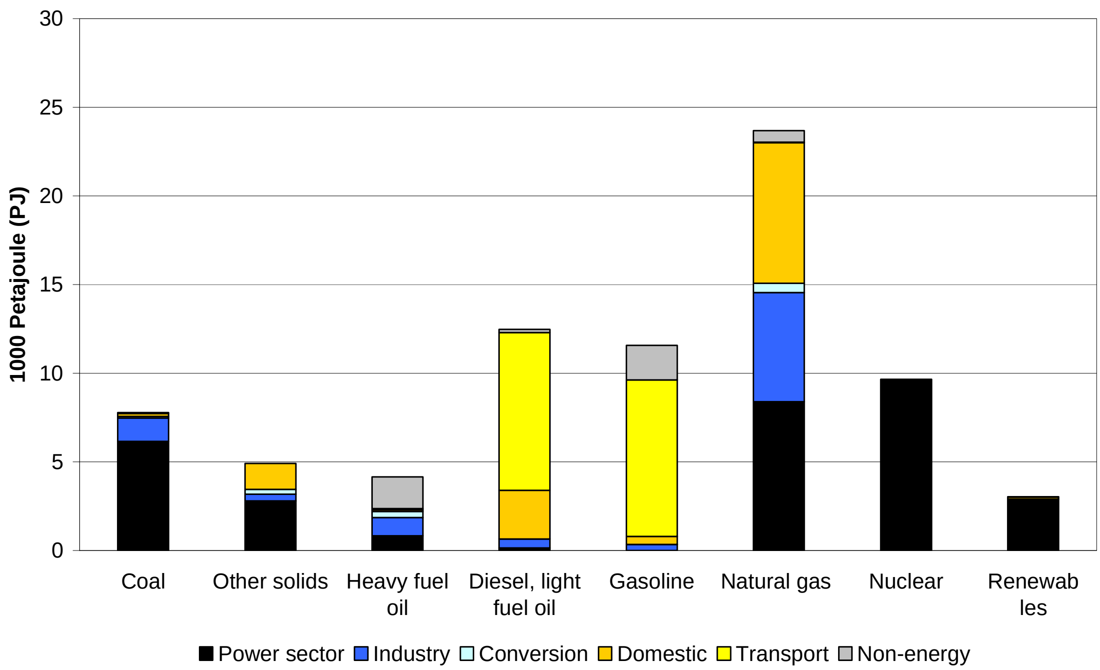

Figure 3.3: Energy consumption of the EU-25 in 2020 as projected in the PRIMES €20 scenario

3.1.3 The baseline energy projection employed for the Clean Air For Europe (CAFE) programme

For comparison and to facilitate the analysis of the robustness of the RAINS cost-effectiveness analysis, the energy projection used in the Clean Air For Europe (CAFE) programme is presented. In 2004, this projection was produced by the PRIMES model with the assumptions on macro-economic development, oil prices, etc. that were employed by DG-TREN in 2003 for its Energy Outlook to 2030 (CEC, 2003). These included, inter alia, the expectation of a $30 oil price in 2020. For CAFE, a €20 carbon price was assumed in addition. Resulting energy projections for the year 2020 are presented in Table 3.8. Compared to the 2006 PRIMES NEC baseline projection, these assumptions resulted in less nuclear power, and lower consumption levels of diesel and gasoline.

Table 3.8: Primary energy consumption of the CAFE baseline scenario in 2020 [PJ].

	Coal	*Biomass, waste*	*Heavy fuel oil*	*Diesel*	*Gasoline, LPG*	*Natural gas*	*Nuclear*	*Other renew.*	*Electr. import[1)]*	*Total*
Austria	70	153	100	290	130	553	0	201	-2	1495
Belgium	91	55	127	461	386	1025	360	17	22	2545
Cyprus	1	5	58	37	30	1	0	4	0	136
Czech Rep.	2379	68	6	79	311	0	16	521	301	3681
Denmark	49	104	25	161	118	395	0	76	-50	878
Estonia	51	21	6	23	22	67	0	2	-3	188
Finland	126	383	56	181	117	353	367	67	14	1664
France	322	551	477	2143	1400	2687	4820	350	-126	12624
Germany	1674	587	355	2422	2064	4810	361	548	5	12826
Greece	299	68	152	349	272	391	0	52	1	1584
Hungary	68	16	50	127	145	559	111	12	9	1095
Ireland	42	35	43	187	140	341	0	18	0	806
Italy	373	324	503	1257	1205	3702	0	393	165	7921
Latvia	2	23	12	34	24	57	0	20	4	177
Lithuania	24	30	20	55	51	147	2	8	0	335
Luxembourg	4	4	1	77	41	63	0	1	17	208
Malta	0	2	21	11	11	0	0	1	0	46
Netherlands	116	109	108	405	594	2127	0	27	52	3537
Poland	1461	299	194	420	495	1494	0	70	-25	4408
Portugal	123	134	157	313	264	326	0	79	2	1398
Slovakia	143	23	85	88	115	332	89	28	-8	896
Slovenia	13	16	14	51	48	103	40	23	-9	297
Spain	219	435	461	1415	982	2135	651	331	2	6632
Sweden	46	523	101	222	256	262	448	275	3	2135
UK	214	316	427	1398	1729	5248	774	185	8	10300
EU-25	7909	4284	3559	12202	10951	27177	8038	3310	383	77812

Data Source: RAINS, based on PRIMES energy balances

3.1.4 Comparison of energy projections for 2020

For the purposes of the revision of the NEC directive, updated information on the expected development on energy use has been collected from national submissions and from Europe-wide model calculations. Taking into account recent economic and political developments and national policy perspectives, these projections show some significant differences compared to the baseline projections developed for the CAFE programme. National projections anticipate significantly higher use of coal and middle distillates (diesel and light fuel oil) and lower consumption of gasoline and natural gas. On the other hand, the updated PRIMES €20 scenario suggests significantly higher use of biomass, heavy fuel oil and nuclear power, and less consumption of natural gas (Figure 3.4)

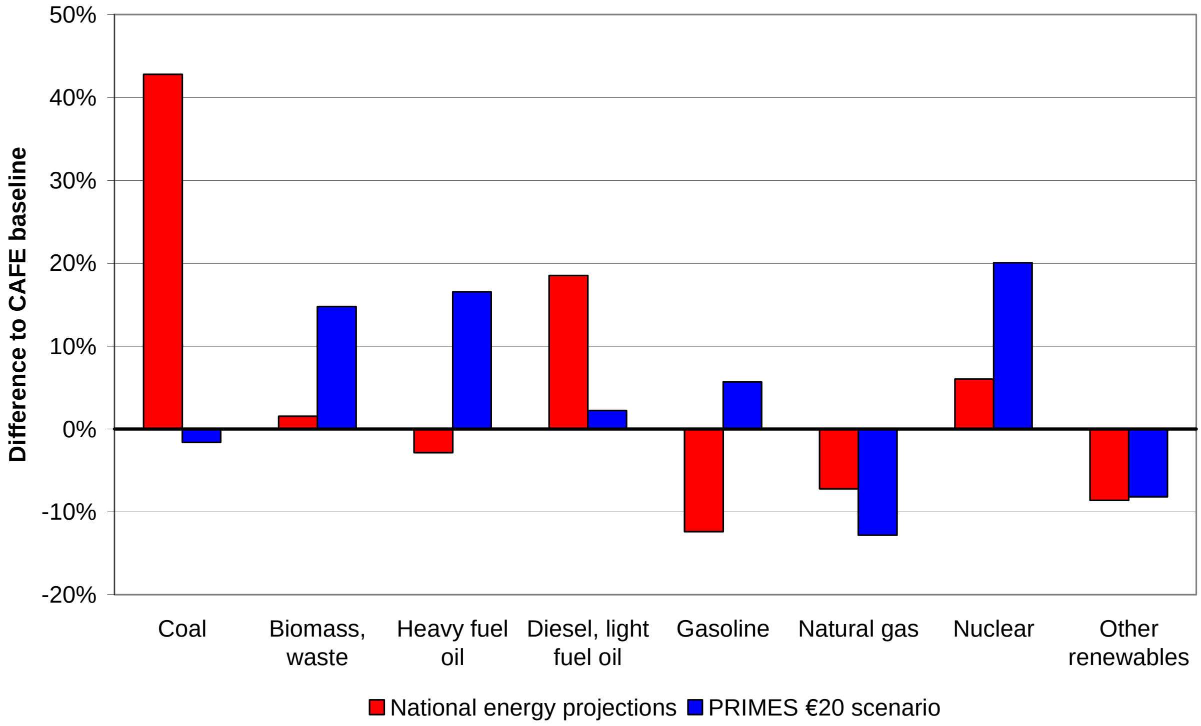

Figure 3.4: Differences in the EU-25 energy projections for 2020 compared to the CAFE baseline

3.2 Agricultural projections

As a starting point for the further analysis, Table 3.9 summarizes the statistics on agricultural activities for the year 2000 as implemented in the RAINS database.

Table 3.9: Agricultural activity date for the year 2000.

	Cattle	*Pigs*	*Chicken and poultry*	*Sheep and goats*	*Horses*	*Fertilizer consumption*	*Fertilizer production*
	1000 animal heads					kt N	
Austria	2155	3348	11787	395	82	121	185
Belgium	3001	7266	52230	176	73	145	1440
Cyprus	54	408	3310	625	7	8	0
Czech Rep.	1609	3315	32043	118	26	213	306
Denmark	1868	11922	21830	91	150	252	133
Estonia	253	300	2366	32	4	22	38
Finland	1057	1298	12570	107	57	167	245
France	20310	14930	270989	10788	444	2571	1494
Germany	14568	25767	118447	2305	520	1848	1308
Greece	566	936	28193	14449	140	285	216
Hungary	805	4834	31244	1219	79	320	290
Ireland	6558	1732	15338	7957	80	408	248
Italy	7245	8307	176722	12464	337	786	428
Latvia	367	394	3105	39	20	29	0
Lithuania	898	936	6373	39	75	99	0
Luxembourg	200	83	70	8	2	17	0
Malta	19	80	830	25	2	0.5	0
Netherlands	4070	13118	104972	1487	118	339	1300
Poland	5723	15447	111900	337	550	896	1497
Portugal	1414	2338	39941	4201	121	170	134
Slovakia	647	1488	12446	399	10	82	286
Slovenia	493	604	5107	118	14	34	0
Spain	6074	24367	169133	26892	499	1255	899
Sweden	1684	1918	16900	437	300	189	94
UK	11134	6482	168973	42340	291	1036	490
EU-25	92772	151618	1416817	127048	4001	11291	11031
Bulgaria	682	1512	14963	3595	364	145	404
Croatia	427	1233	11251	608	15	116	328
Romania	3051	5848	77993	8679	888	240	872
Turkey	11219	3	246477	38030	989	1276	0
Norway	987	609	12080	1841	48	103	618
Switzerland	1543	1498	6983	483	62	55	15

Data source: RAINS, based on EUROSTAT statistics

3.2.1 National agricultural projections for 2020

In addition to the request for energy projections, DG-Environment of the European Commission has invited all Member States to provide official national projections of their agricultural activities up to 2020 as a basis for the revision of the NEC directive. These projections should reflect national agricultural policies (as laid down, e.g., in governmental plans). Furthermore, these projections must include all necessary measures to comply with the Kyoto targets on greenhouse gas emissions and the burden sharing agreement for 2012. For 2020, it should be assumed as a minimum that the Kyoto emission caps remain unchanged. With these requirements, the national agricultural projections for the revision of the NEC Directive should be consistent with the agricultural projections presented by the Member States to UNFCCC in their Fourth National Communications in 2006.

In the course of the bilateral consultations in 2006, 17 Member States have supplied national agricultural projections to IIASA for implementation into the RAINS model (Table 3.3).

Collectively, these national projections constitute the "National Projections" baseline scenario for the revision of the NEC directive. For those Member States that have not provided their own agricultural projection, the "National Projections" baseline case assumes by default the agricultural development as outlined by the CAPRI (EEA, 2004) and EFMA (EFMA, 2005) agricultural and fertilizer projection (see Section 3.2.2). For Member States for which CAPRI and/or EFMA projections are unavailable, projections developed by the Food and Agricultural Organization (FAO) have been used (Bruinsma, 2003).

Table 3.10: Data sources for the "National Projections" NEC baseline scenario.

	Data source	*Date of last information exchange*	*Comments*
Austria	National (2006)	9 January 2006	
Belgium	National (2006)	24 February 2006	
Cyprus	FAO (2003), EFMA (2005)		
Czech Rep.	National (2005)	13 September 2005	
Denmark	National (2005)	15 October 2005	
Estonia	National (2006)	4 May 2006	
Finland	National (2005)	14 October 2005	
France	National (2004)	18 May 2004	
Germany	CAPRI (2004), EFMA (2005)		
Greece	CAPRI (2004), EFMA (2005)		
Hungary	National (2006)		Projection submitted to UNECE
Ireland	National (2006)	18 September 2006	Base year statistics not completely clarified
Italy	National (2006)	17 February 2006	
Latvia	National (2006)	7 February 2006	
Lithuania	CAPRI (2004), EFMA (2005)		
Luxembourg	CAPRI (2004), EFMA (2005)		
Malta	FAO (2003), EFMA (2005)		
Netherlands	National (2006)	14 September 2006	
Poland	National (2005)	19 October 2005	
Portugal	National (2006)	15 September 2006	Some territorial issues remain to be solved
Slovakia	CAPRI (2004), EFMA (2005)		
Slovenia	National (2006)	6 September 2006	
Spain	CAPRI (2004), EFMA (2005)		
Sweden	National (2006)	7 February 2006	
UK	National (2006)	27 July 2006	
Bulgaria	FAO (2003)		
Croatia	FAO (2003)		
Romania	FAO (2003)		
Turkey	FAO (2003)		
Norway	National (2005)	10 February 2005	
Switzerland	National (2006)	30 August 2006	

Table 3.11: National projections of agricultural activities for the year 2020. Source: RAINS, based on national submissions to IIASA.

	Cattle	*Pigs*	*Chicken and poultry*	*Sheep and goats*	*Horses*	*Fertilizer consumption*	*Fertilizer production*
	1000 animal heads					kt N	
Austria	1896	3228	13007	389	87	102	225
Belgium	2586	8073	54005	129	73	142	1440
Cyprus	48	457	4830	655	7	7	0
Czech Rep.	1400	3800	36234	260	28	230	310
Denmark	1371	14251	22326	98	165	180	0
Estonia	222	448	2640	87	4	21	38
Finland	491	1270	13113	116	65	145	210
France	19145	16327	226966	9971	458	2313	1374
Germany	12216	22490	89767	1592	770	1688	1000
Greece	520	994	23923	14819	140	202	200
Hungary	907	7000	43000	1600	82	398	250
Ireland	4937	1503	13200	4941	85	320	0
Italy	6418	9181	197983	11320	337	799	428
Latvia	350	508	5091	55	16	35	0
Lithuania	766	1208	12782	38	65	120	0
Luxembourg	189	94	86	7	2	16	0
Malta	18	67	953	26	2	1	0
Netherlands	3506	11181	108629	1951	165	272	1000
Poland	4850	15598	171500	340	355	963	1450
Portugal	1514	2225	30772	4061	93	207	172
Slovakia	693	1901	11602	359	10	101	270
Slovenia	527	665	5552	142	17	33	0
Spain	6634	29633	184073	27037	499	1007	850
Sweden	1455	2490	20000	395	300	170	65
UK	8317	4835	175620	33813	291	976	500
EU-25	80976	159427	1467652	114201	4116	10448	9782
Bulgaria	677	931	20125	2411	365	151	350
Croatia	566	1273	12589	916	14	116	300
Romania	2855	6500	104000	8091	900	254	800
Turkey	14561	3	306826	43972	650	1200	0
Norway	907	633	14290	1416	55	90	630
Switzerland	1403	1348	7490	484	72	50	15

For the EU-25 as a whole, these national projections anticipate between 2000 and 2020 for cattle a 13 percent decline in livestock numbers (dairy cattle drops by about 18 percent while beef cattle by about 10 percent), for sheep a reduction by 10 percent and a four to five percent increase of pigs and poultry.

While these national projections reflect the latest governmental views of the individual Member States on the future agricultural development, there is no guarantee for Europe-wide consistency in terms of assumptions on economic development trends, and national as well EU-wide agricultural policies.

3.2.2 CAPRI agricultural projection including the CAP mid-term review

As an alternative to the national agricultural projections, EU-wide livestock projections developed for a CAPRI model study for the European Environment Agency study (EEA, 2004) and mineral fertilizer projections provided by the European fertilizer association EFMA have been implemented into RAINS (Table 3.12). The methodology used for CAPRI projections combines the standard structure of the agricultural sector model CAPSIM with amendments to systematically integrate external forecasts. CAPSIM is a partial equilibrium modelling tool with behavioural functions for activity levels, input demand, consumer demand and processing. It is designed for policy relevant analysis of the CAP and consequently covers the whole of agriculture of the EU Member States.

Table 3.12: CAPRI model projections of agricultural activities of fertilizer production and consumption for the year 2020. Source: RAINS, based on CAPRI results and EFMA projections.

	Cattle	*Pigs*	*Chicken and poultry*	*Sheep and goats*	*Horses*	*Fertilizer consumption*	*Fertilizer production*
	1000 animal heads					kt N	
Austria	1950	3532	11225	337	87	92	225
Belgium	2806	8241	67363	146	73	142	1440
Cyprus	48	457	4830	655	7	7	0
Czech Rep.	1435	3913	41035	171	28	333	310
Denmark	1343	13821	20533	91	165	190	0
Estonia	214	300	3052	36	4	30	38
Finland	886	1271	12152	79	65	156	210
France	18723	17408	317895	10986	458	2355	1374
Germany	12216	22490	89767	1592	770	1688	1000
Greece	520	994	23923	14819	140	202	200
Hungary	801	4695	31470	1446	82	392	250
Ireland	5306	1994	15621	7906	80	307	0
Italy	5794	9506	187656	9033	337	558	428
Latvia	270	409	3811	76	16	32	0
Lithuania	766	1208	12782	38	65	120	0
Luxembourg	189	94	86	7	2	16	0
Malta	18	67	953	26	2	1	0
Netherlands	3631	10892	124043	1570	165	231	1000
Poland	4887	19712	125282	476	355	1103	1450
Portugal	957	2668	31810	4204	93	87	172
Slovakia	693	1901	11602	359	10	101	270
Slovenia	528	773	5032	171	17	31	0
Spain	6634	29633	184073	27037	499	1007	850
Sweden	1747.2	1549.34	20160.48	421.57	300	159	65
UK	10732	5047	173346	33258	291	995	500
EU-25	83092	162575	1519501	114940	4111	10333	9782
Bulgaria	677	931	20125	2411	365	151	350
Croatia	566	1273	12589	916	14	116	300
Romania	2855	6500	104000	8091	900	254	800
Turkey	14560.9	3	306826	43972	650	1200	0
Norway	897	725	16325	1784	55	97	630
Switzerland	1422	1419	8477	501	72	47	15

The reference projection (EEA, 2004), referred further as the CAPRI projections, explores the long term impact of the Common Agricultural Policy (CAP) on the European Union agriculture. This scenario the is based on existing exogenous projections (e.g, FAPRI, FAO, DG Agri) for cropping areas, production, consumption, feed use, supplemented by own trend projections.

For the EU-25 as a whole, these CAPRI model projections anticipate between 2000 and 2020 largely similar changes as the national projections. They foresee about 21 percent drop in dairy cattle numbers followed by about seven percent decline in beef. The development of the beef sector depends on the assumption of a continued milk quota regime with expected milk yield increases (approximately 30 percent on average) and on the long term demand shift from beef to pig and poultry meat. The latter (in terms of livestock numbers) are projected to increase by about 7.5 percent during the period. More details on the modelling approach and results of CAPRI reference run can be found in EEA (2004).

The mineral nitrogen fertilizer projection for EU-25 as well as Norway and Switzerland was developed by EFMA (2005). EFMA prepares such forecast annually using quantitative information from various sources (e.g. from USDA, FAPRI, DG Agri) and combines this with qualitative analyses made by EFMA experts. The results are consulted with national experts. Overall for EU-25, EFMA projects a nine percent decline in N-fertilizer use between 2000 and 2015.

3.2.3 The baseline agricultural projection employed for the Clean Air For Europe (CAFE) programme

For comparison and to facilitate the analysis of the robustness of the RAINS cost-effectiveness analysis, the agricultural projections used in the Clean Air For Europe (CAFE) programme is presented. In 2004, this projection was produced by the CAPRI model before the mid-term review of the Common Agricultural Policy of the EU.

Compared to the updated projections that take the mid-term review of the CAP into account, the CAFE scenario expects larger increase in pig numbers, slightly lower sheep count and less optimistic assumptions about increased efficiency of nitrogen fertilizer use. For other animal categories the differences on the EU-25 level are less than three percent compared to either of the current scenarios. Large differences emerge, however, with projections for individual countries.

Table 3.13: Projections of agricultural activities as employed by the CAFE programme for the year 2020. Source: RAINS, based on CAPRI results.

	Cattle	*Pigs*	*Chicken and poultry*	*Sheep and goats*	*Horses*	*Fertilizer consumption*	*Fertilizer production*
	1000 animal heads					kt N	
Austria	1842	4119	15875	389	63	118	182
Belgium	2587	8073	54005	129	73	138	1440
Cyprus	48	457	4830	655	7	8	0
Czech Rep.	1308	3452	36201	270	28	225	320
Denmark	1686	13276	23811	85	165	180	115
Estonia	244	276	2087	30	6	57	60
Finland	977	1654	12440	105	65	162	210
France	17519	17368	343251	9905	381	2146	950
Germany	12645	28914	129072	2097	770	1748	1000
Greece	510	966	33157	13820	140	210	180
Hungary	765	3882	44285	1278	82	398	370
Ireland	6467	1946	13983	3651	80	317	0
Italy	6399	9155	183730	11132	313	765	427
Latvia	451	420	3350	75	23	58	56
Lithuania	804	1146	8623	40	65	344	550
Luxembourg	174	86	72	8	2	17	0
Malta	18	67	953	26	2	1	0
Netherlands	3531	14651	119302	1407	125	215	1000
Poland	4848	20738	60833	328	330	996	1500
Portugal	1030	2576	41469	4196	91	163	110
Slovakia	564	1321	19769	418	10	77	275
Slovenia	404	731	11270	124	14	38	0
Spain	5215	25509	141770	25357	505	1003	800
Sweden	1521	2570	18840	427	300	190	90
UK	9943	8258	169103	28844	291	1243	400
EU-25	81500	171611	1492081	104796	3931	10817	10035

3.3 Emission control legislation

The NEC baseline projections estimate future emissions on the basis of the development of emission generating activities, country- and sector-specific emission factors and the progressing implementation rate of already decided emission control legislation. The analysis is based on a detailed inventory of national emission control legislation (including the transposition of EU-wide legislation) as of mid 2006. The baseline emission projections consider legislation listed in Table 3.14 to Table 3.18, and that they are fully implemented in all Member States according to the foreseen time schedule. They ignore, however, further measures that might be necessary to meet the national emission ceilings in 2010, if they are not already put into national legislation. Furthermore, the baseline projections neglect emission reduction measures that could be required for compliance with the EU air quality limit values, especially for NO_2 and PM10.

Table 3.14: Legislation considered in the baseline projections for SO_2 emissions

Large combustion plant directive
Directive on the sulphur content in liquid fuels
Directives on quality of petrol and diesel fuels
IPPC legislation on process sources
National legislation and national practices (if stricter)

Table 3.15: Legislation considered in the baseline projections for NO_x emissions

Large combustion plant directive
EURO standards, including the Commission proposal on Euro5 for light duty vehicles
EU emission standards for motorcycles and mopeds
Legislation on non-road mobile machinery
Implementation failure of EURO-II and Euro-III for diesel (heavy duty and light duty) vehicles
IPPC legislation for industrial processes
National legislation and national practices (if stricter)

Table 3.16: Legislation considered in the baseline projections for VOC emissions

Stage I directive
Directive 91/441 (carbon canisters)
EURO standards, including the Commission proposal on Euro5 for light duty vehicles
Fuel directive (RVP of fuels)
Solvents directive
Product directive (paints)
National legislation, e.g., Stage II

Table 3.17: Legislation considered in the baseline projections for NH_3 emissions

No EU-wide legislation
National legislations
Current practice

Table 3.18: Legislation considered in the baseline projections for PM2.5 emissions

Large combustion plant directive
EURO standards, including the Commission proposal on Euro5 for light duty vehicles
Emission standards for motorcycles and mopeds
Legislation on non-road mobile machinery
IPPC legislation on process sources
National legislation and national practices (if stricter)

3.4 Summary of changes from the CAFE baseline scenario

In summary, the NEC baseline projections include the following changes compared to the CAFE baseline scenario developed in 2004:

- National projections on energy and agricultural activities, non-energy sources of VOC and industrial processes.
- A new PRIMES projection with updated assumptions on economic development, international oil prices and climate policies.
- Inclusion of the Commission proposal on Euro5 for light duty vehicles into the baseline set of policy measures
- Modified emission factors for diesel vehicles reflecting the recent findings of the ARTEMIS project/COPERT-IV model.
- Updated assumptions about the implementation of current legislation according to the national expectations.
- Updated information on ammonia emissions, based on national information following the improved chapters on agriculture in the European Emission Inventory Guidebook.
- The calculation of ammonia emissions from dairy cows takes account of the impacts of increasing milk yield on nitrogen excretion.
- Explicit consideration of the IPPC Directive for pigs and poultry for all EU Member States as well as the voluntary implementation of IPPC threshold for cattle farms in some countries.
- Updated emission factors and removal efficiencies for PM and VOC emissions from the residential sector
- Improved treatment of VOC emissions from the coil sector, decorative paints, printing industry, domestic use of solvents, vehicle refinishing
- Update of activity data on paint consumption and wood coating based on new information from industry and national experts.

4 Emission projections

4.1 Carbon dioxide (CO_2)

Although not subject of the NEC directive, this report examines emissions of the greenhouse gas CO_2 that are associated with the energy development assumed by the various projections. Significant interactions and co-benefits have been demonstrated between the mitigation of CO_2 emissions and the reduction of SO_2 and other air pollutants.

The future development of CO_2 emissions implied by the examined energy projections is summarized in Table 4.1. The national projections of the EU-25 result in 2020 in two percent higher CO_2 emissions compared to the level of emissions in the base year of the Kyoto protocol (1987-1990). With the assumption of a carbon price of €20/ton SO_2, the PRIMES model with the recent assumptions on economic development and energy prices simulates CO_2 emissions of the EU-25 to drop by seven percent compared to the Kyoto base year level. The earlier analysis for CAFE conducted with the PRIMES model resulted in 10 percent decline of CO_2 emissions between the Kyoto base year and 2020. Note that these RAINS emission calculations refer to the UNFCCC calculation basis for national inventories and exclude (increasing) emissions of international aviation and marine bunkers in Europe, which are routinely included in the CO_2 computations of the PRIMES model.

There are significant variations in the development of CO_2 emissions for individual countries (Figure 4.1).

Table 4.1: CO_2 emissions [Mt CO_2/year]

	UNFCCC base year	*2000*	*2020 4th National Communications to UNFCCC*	*Computed from the energy projection for 2020* National energy projections	PRIMES €20	CAFE baseline	*Change in 2020 compared to UNFCCC base year* National energy projections	PRIMES €20	CAFE baseline
Austria	61	65		77	72	69	26%	18%	13%
Belgium	119	126	132	131	122	121	10%	2%	2%
Cyprus	5	7		9	9	9	87%	87%	92%
Czech Rep.	164	126	101	123	110	90	-25%	-33%	-45%
Denmark	53	53		54	46	46	2%	-14%	-13%
Estonia	38	17		27	15	12	-30%	-60%	-69%
Finland	56	58	65	59	57	61	5%	1%	8%
France	397	405	470	452	378	431	14%	-5%	9%
Germany	1015	860		854	773	734	-16%	-24%	-28%
Greece	84	104	137	119	119	106	42%	42%	27%
Hungary	85	59	80	68	68	59	-19%	-20%	-30%
Ireland	32	45		59	46	47	85%	46%	48%
Italy	431	472		503	504	439	17%	17%	2%
Latvia	19	7	17	17	11	9	-7%	-39%	-54%
Lithuania	39	14	18	21	21	19	-46%	-46%	-50%
Luxembourg	12	9		11	11	12	-5%	-5%	0%
Malta	2	2		3	3	3	56%	43%	48%
Netherlands	158	169		206	179	180	30%	13%	14%
Poland	477	315		350	326	305	-26%	-32%	-36%
Portugal	44	66	80	80	72	80	84%	65%	83%
Slovakia	59	39	57	59	54	49	-1%	-8%	-17%
Slovenia	16	15		17	17	15	7%	7%	-4%
Spain	228	308	450	435	335	324	91%	47%	42%
Sweden	56	53	64	58	68	63	2%	21%	12%
UK	589	559	537	536	504	515	-9%	-14%	-12%
EU-25	4238	3954		4329	3921	3799	2%	-7%	-10%
Bulgaria	98	46	50	48	48		-51%	-51%	
Croatia	23	23	25	27	27		19%	19%	
Romania	184	92	117	143	143		-22%	-22%	
Turkey	126	223	272	389	389		208%	208%	
Norway	34	38	41	48	39		40%	15%	
Switzerland	45	42	44	40	44		-10%	-1%	

Data sources: RAINS/GAINS computations; 4th National Communications to UNFCCC

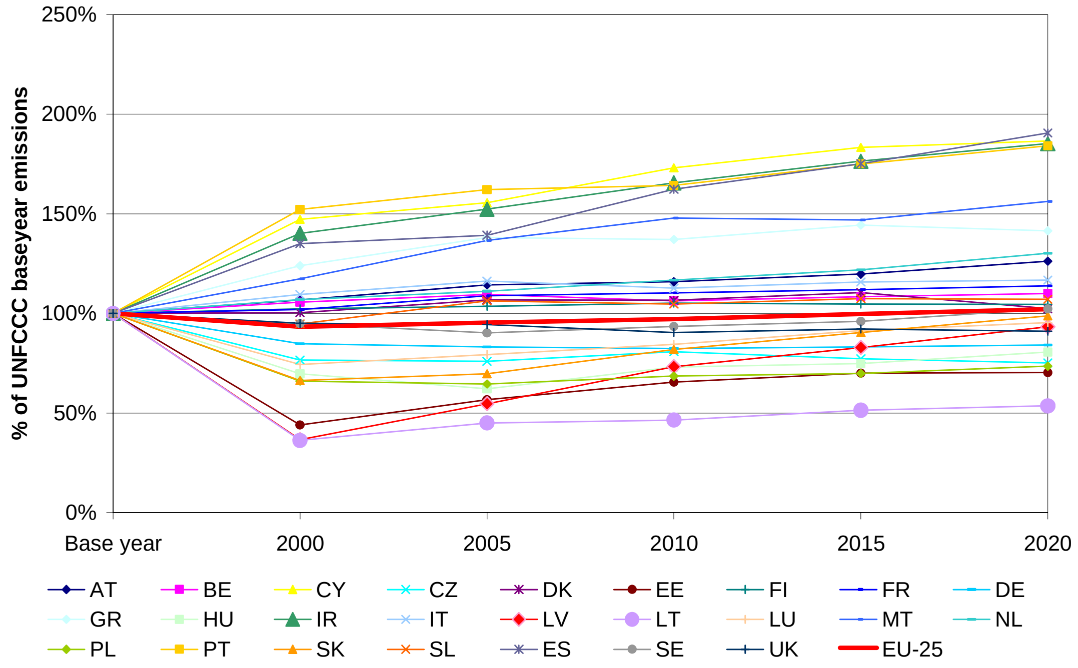

Figure 4.1: CO_2 emissions from the national energy projections of the EU-25 Member States

4.2 Sulphur dioxide (SO_2)

While the examined energy projections agree on a significant decline of EU-25 SO_2 emissions between 2000 and 2020 due to reduced coal consumption and progressing implementation of emission control measures, significant differences between the energy projections occur. For 2020, the national projections point to a 56 percent decline in SO_2 emissions relative to 2000, while the PRIMES €20 scenario, which estimates 32 percent less coal consumption than the national projections, results in a 65 percent decline. This decline is slightly less than the reduction associated with the CAFE baseline scenario (-68 percent). Compared to the emissions of the CAFE baseline scenario in 2020, the updated PRIMES projections result in eight percent higher SO_2 baseline emissions, while the national projections see even 38 percent higher emissions. It has been noted above that these differences in SO_2 emissions coincide with differences in CO_2 emissions, and that the national CO_2 projections for 2020 seem to be significantly higher than the ambition levels of current EU climate policies.

Table 4.2: SO_2 emissions [kt SO_2/year]

	2000	*2010* National energy projections	*2010* Emission ceiling	*Projection for 2020* National energy projections	PRIMES €20 scenario	CAFE baseline
Austria	34	21	39	20	23	26
Belgium	175	98	99	86	78	83
Cyprus	48	18	39	8	8	8
Czech Rep.	252	237	265	179	83	53
Denmark	28	20	55	21	19	13
Estonia	92	110	100	103	12	10
Finland	77	70	110	71	56	62
France	658	495	375	494	296	345
Germany	627	469	520	443	305	332
Greece	493	151	523	94	94	110
Hungary	485	145	500	61	111	88
Ireland	132	35	42	37	25	19
Italy	755	340	475	345	314	281
Latvia	14	23	101	19	9	8
Lithuania	48	20	145	15	15	22
Luxembourg	4	2	4	2	2	2
Malta	34	6	9	7	7	2
Netherlands	75	67	50	77	54	64
Poland	1509	1165	1397	857	778	554
Portugal	274	131	160	86	68	81
Slovakia	127	66	110	78	47	33
Slovenia	98	26	27	22	18	16
Spain	1458	450	746	385	352	335
Sweden	46	43	67	41	41	50
UK	1167	458	585	275	217	209
EU-25	8709	4673	6543	3826	3035	2805
Bulgaria	847	441		116	116	
Croatia	108	70		65	65	
Romania	773	331		139	139	
Turkey	1646	1145		911	911	
Norway	26	25		26	25	
Switzerland	17	15		14	16	

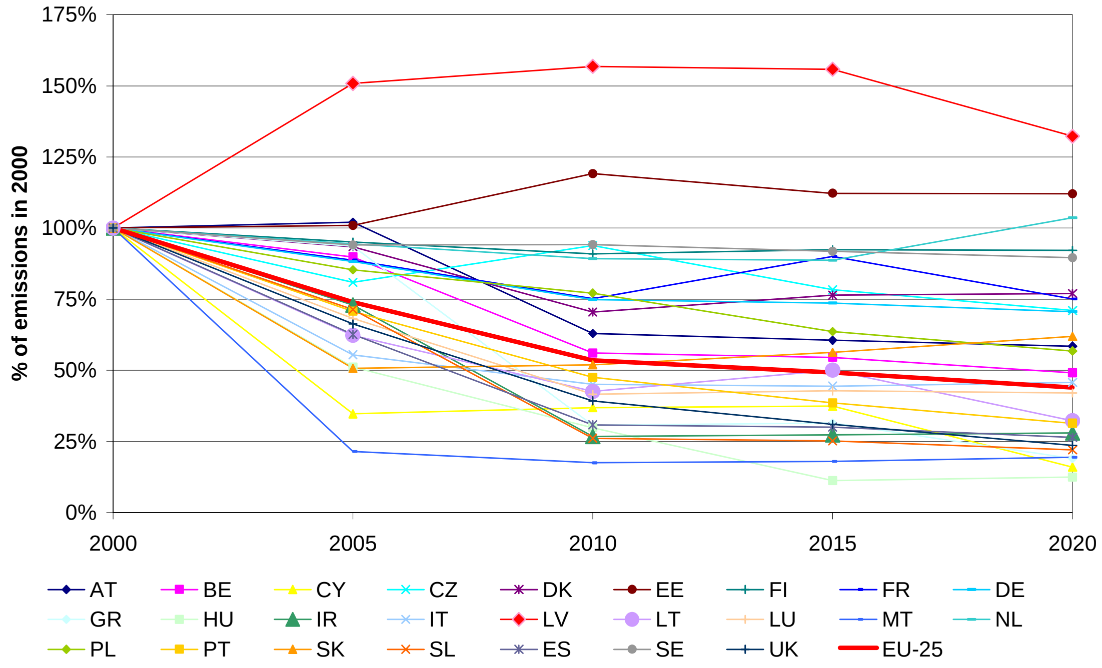

Figure 4.2: SO_2 resulting emissions from the national energy projections of the EU-25 Member States

Table 4.3: SO_2 emissions of the EU-25 by SNAP sector [in kt]

	2000	*2010*	*2020*		
		National energy projections	National energy projections	PRIMES €20 scenario	CAFE baseline
SNAP 1: Combustion in energy industries	5615	2536	1709	1096	1006
SNAP 2: Non-industrial combustion plants	718	513	476	314	202
SNAP 3: Combustion in manufacturing industry	1357	937	959	904	777
SNAP 4: Production processes	632	537	539	560	596
SNAP 5: Extraction and distribution	0	0	0	0	0
SNAP 6: Solvent use	0	0	0	0	0
SNAP 7: Road transport	152	15	13	18	18
SNAP 8: Other mobile sources and machinery	221	114	117	133	199
SNAP 9: Waste treatment and disposal	8	6	6	3	3
SNAP 10: Agriculture	7	7	7	7	4
Total	8709	4664	3826	3035	2805

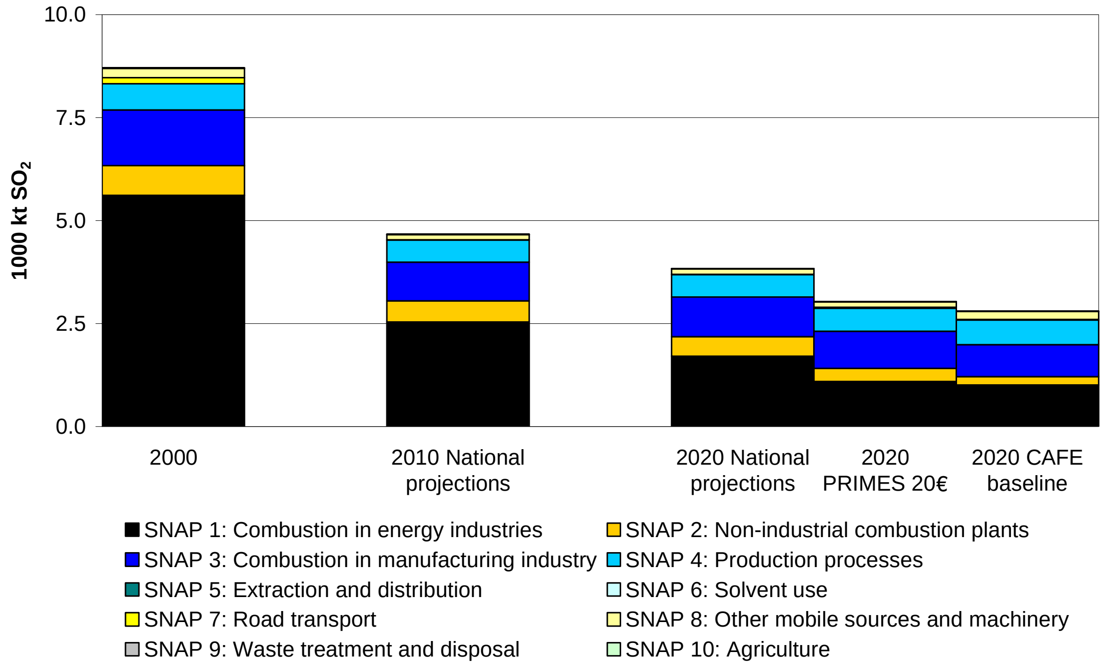

Figure 4.3: SO_2 emissions of the EU-25 by SNAP sector

4.3 Emission projections for nitrogen oxides (NO_x)

As for SO_2, all energy projections indicate a significant decline of NO_x emissions between 2000 and 2020. However, the alternative assumptions on economic and energy development adopted by the national projections and the revised PRIMES €20 scenario yield an increase in NO_x baseline emissions by 15 and seven percent, respectively, compared to the CAFE baseline projection (Table 4.4). Obviously, there are large variations across Member States (Figure 4.4). The overall increase in EU-25 emissions is mainly related to the 50 percent higher emissions from the power sector due to larger coal figures on coal consumption (Table 4.5).

For 2020, the national energy projections together with the currently adopted emission control measures and the lower than anticipated performance of some emission control equipment for mobile sources would lead to sometimes substantially higher NO_x emissions than imposed by the National Emission Ceilings Directive. With projected NO_x emissions higher than the national ceilings in 13 out of 25 countries, total EU-25 NO_x emissions would exceed the cumulative emissions ceilings by 6.5 percent.

It is also interesting to note that in this baseline projection, which ignores the obligations of the NECD directive for maintaining emission ceilings also beyond 2010, NO_x emissions increase after 2010 in many countries due to a further growth in economic activity levels.

Table 4.4: NO_x emissions [kt NO_x/year]

	2000	*2010* National energy projections	*2010* Emission ceiling	*Projection for 2020* National energy projections	PRIMES €20 scenario	CAFE baseline
Austria	202	168	103	132	112	127
Belgium	350	252	176	206	181	190
Cyprus	26	18	23	15	15	18
Czech Rep.	316	297	286	189	164	113
Denmark	213	167	127	128	113	105
Estonia	39	39	60	30	20	15
Finland	208	163	170	131	125	117
France	1471	1157	810	907	782	819
Germany	1747	1180	1051	944	928	808
Greece	332	260	344	204	204	209
Hungary	187	140	198	106	99	83
Ireland	132	99	65	77	65	63
Italy	1352	1061	990	779	724	663
Latvia	34	42	61	31	21	15
Lithuania	51	43	110	30	30	27
Luxembourg	33	24	11	16	16	18
Malta	8	10	8	9	8	4
Netherlands	410	288	260	241	236	240
Poland	839	679	879	425	452	364
Portugal	279	209	250	160	144	156
Slovakia	109	84	130	73	64	60
Slovenia	60	51	45	37	26	24
Spain	1349	1133	847	838	827	681
Sweden	228	179	148	156	160	150
UK	1852	1181	1167	869	746	817
EU-25	11827	8924	8319	6732	6263	5888
Bulgaria	163	156		108	108	
Croatia	87	94		104	104	
Romania	329	332		258	258	
Turkey	822	781		703	703	
Norway	222	190		171	163	
Switzerland	89	59		45	49	

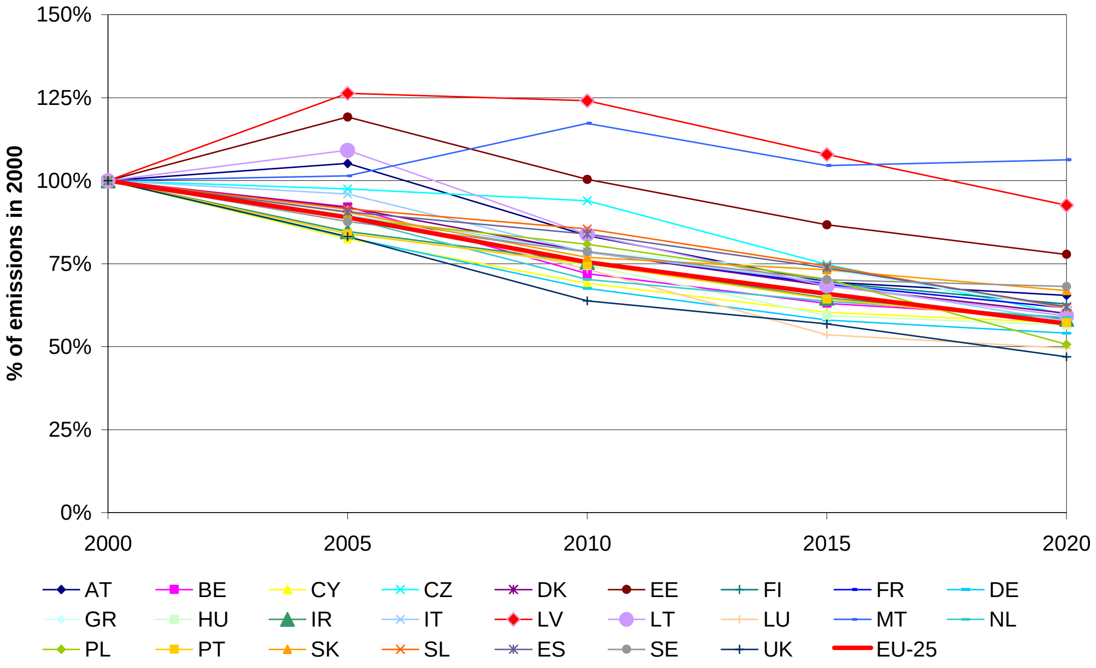

Figure 4.4: NO_x emissions resulting from the national energy projections of the EU-25 Member States

Table 4.5: NO_x emissions of the EU-25 by SNAP sector [in kt]

	2000	*2010*		*2020*	
		National energy projections	National energy projections	PRIMES €20 scenario	CAFE baseline
SNAP 1: Combustion in energy industries	2336	1934	1418	1282	995
SNAP 2: Non-industrial combustion plants	687	684	683	692	596
SNAP 3: Combustion in manufacturing industry	1375	1307	1380	1255	1083
SNAP 4: Production processes	191	202	209	196	186
SNAP 5: Extraction and distribution	0	0	0	0	0
SNAP 6: Solvent use	0	0	0	0	0
SNAP 7: Road transport	5448	3280	1838	1671	1809
SNAP 8: Other mobile sources and machinery	1762	1494	1180	1144	1204
SNAP 9: Waste treatment and disposal	10	8	8	7	7
SNAP 10: Agriculture	17	15	15	15	8
Total	11826	8923	6732	6263	5888

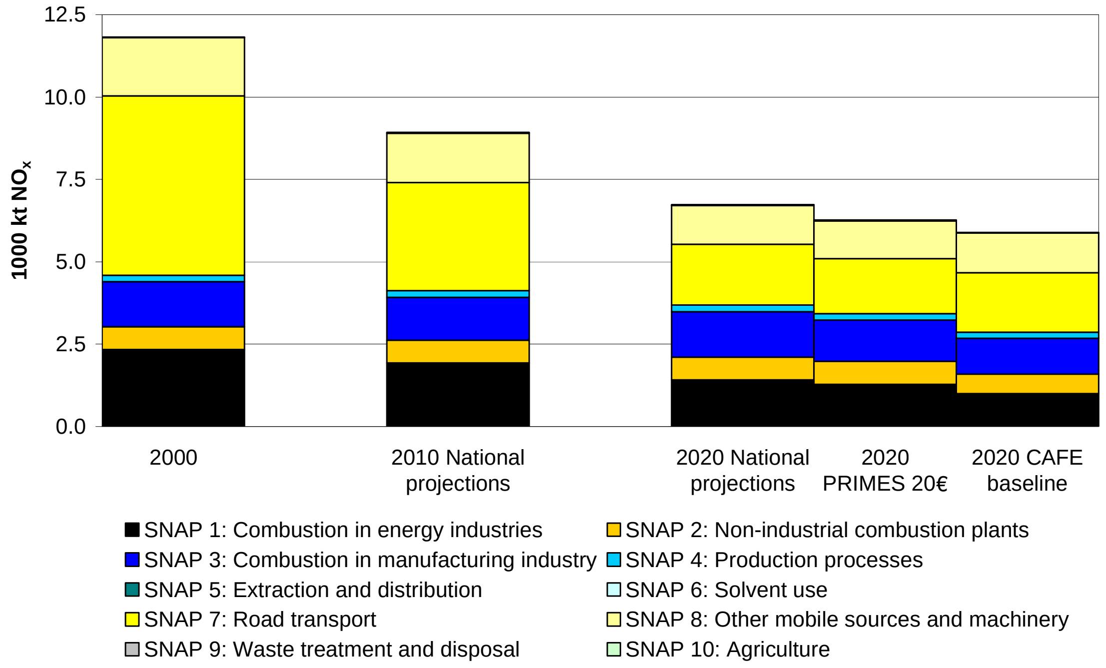

Figure 4.5: NO_x emissions of the EU-25 by SNAP sector

4.4 Emission projections for ammonia (NH_3)

The CAFE baseline projection, which was developed before the mid-term review of the EU Common Agricultural Policy, envisaged a slight decline of ammonia emissions of three percent between 2000 and 2020. In contrast, both the national projections as well as the CAPRI model associate structural changes in European agriculture with the mid-term review that should lead to a 10-11 percent decline in emissions (Table 4.6, Table 4.7). While national projections and the CAPRI model lead to similar results for the EU-25 as a whole, expectations for individual countries are sometimes significantly different (

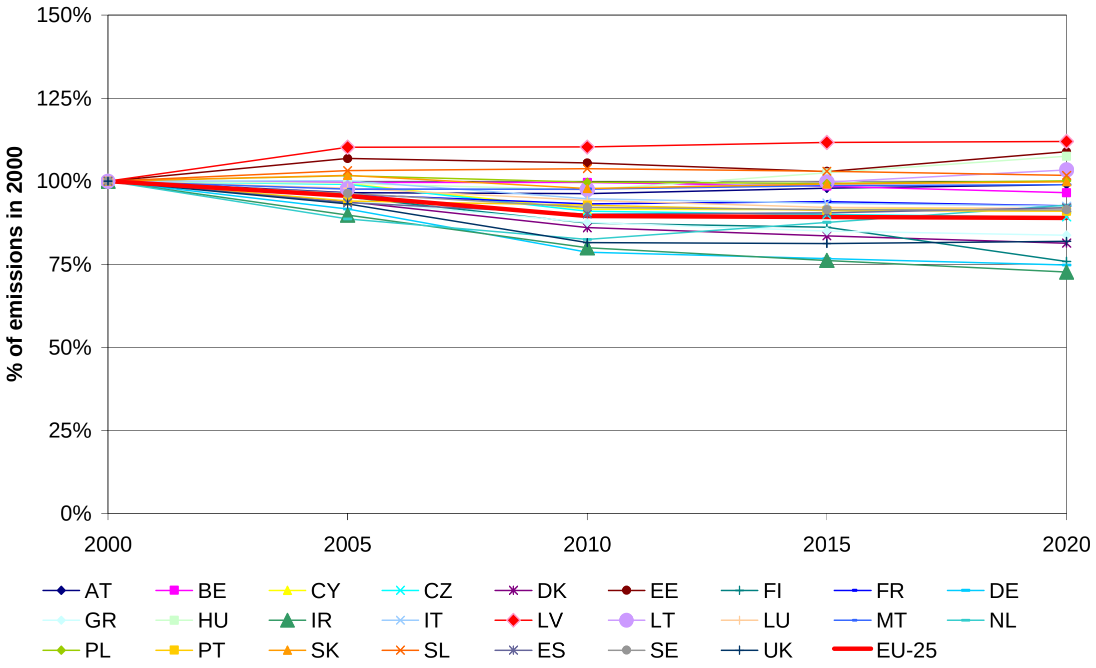

Figure 4.6).

Table 4.6: NH_3 emissions [kt NH_3/year]

	2000	*2010*	*2010*	*Projection for 2020*		
		National agricultural projections	Emission ceiling	National agricultural projections	CAPRI mid-term scenario	CAFE baseline
Austria	60	57	66	59	59	54
Belgium	87	87	74	84	86	76
Cyprus	7	7	9	7	7	6
Czech Rep.	84	76	80	75	77	65
Denmark	90	78	69	73	73	78
Estonia	9	10	29	10	10	12
Finland	35	30	31	26	32	32
France	691	644	780	640	664	702
Germany	602	473	550	450	453	603
Greece	54	48	73	45	46	52
Hungary	77	75	90	83	69	85
Ireland	122	98	116	89	100	121
Italy	428	406	419	396	366	399
Latvia	13	14	44	14	12	16
Lithuania	37	36	84	39	39	57
Luxembourg	6	6	7	6	6	6
Malta	2	1	3	2	2	1
Netherlands	151	125	128	140	133	140
Poland	317	316	468	317	349	333
Portugal	77	73	90	66	62	67
Slovakia	31	30	39	31	30	33
Slovenia	20	21	20	20	19	20
Spain	394	355	353	363	362	370
Sweden	55	50	57	50	48	49
UK	328	267	297	268	282	310
EU-25	3778	3383 0	3976	3353	3386	3686
Bulgaria	70	64		66	65	
Croatia	28	30		32	32	
Romania	151	146		147	147	
Turkey	429	457		499	500	
Norway	24	21		20	21	
Switzerland	53	48		45	50	

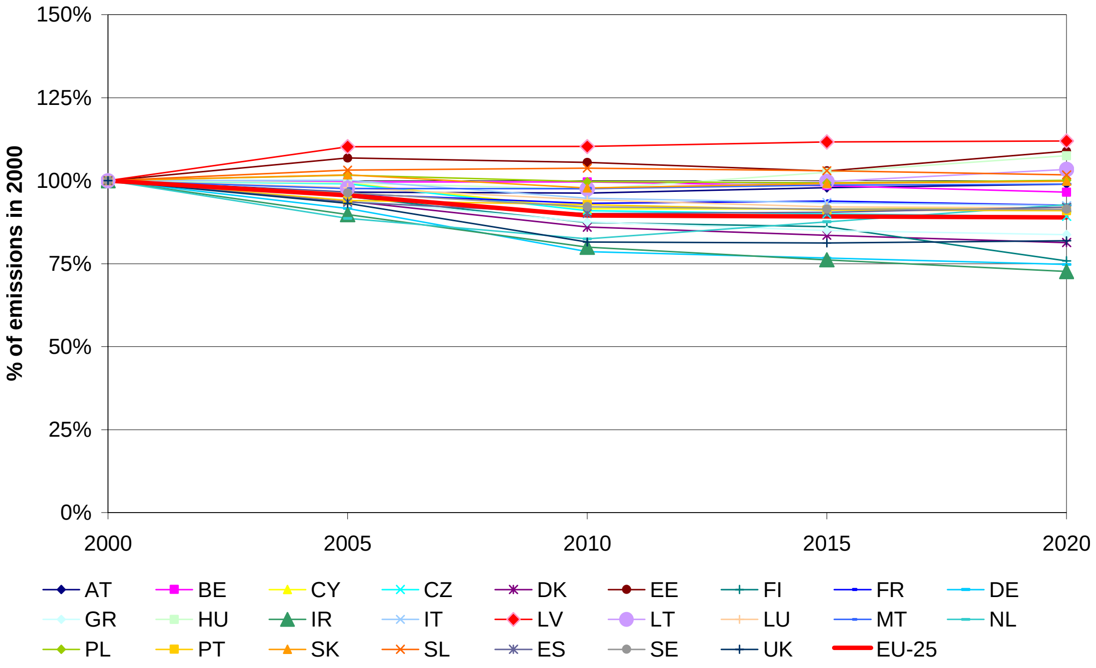

Figure 4.6: NH_3 emissions resulting from the national activity projections of the EU-25 Member States

Table 4.7: NH_3 emissions of the EU-25 by SNAP sector [in kt]

	2000	*2010*	*2020*		
		National agricultural projections	National agricultural projections	CAPRI mid-term scenario	CAFE baseline
SNAP 1: Combustion in energy industries	5	7	12	16	24
SNAP 2: Non-industrial combustion plants	17	16	16	17	22
SNAP 3: Combustion in manufacturing industry	3	5	5	3	3
SNAP 4: Production processes	69	63	62	62	54
SNAP 5: Extraction and distribution	0	0	0	0	0
SNAP 6: Solvent use	0	0	0	0	0
SNAP 7: Road transport	78	42	19	21	20
SNAP 8: Other mobile sources and machinery	1	1	1	1	1
SNAP 9: Waste treatment and disposal	149	142	140	138	145
SNAP 10: Agriculture	3456	3106	3098	3127	3417
Total	3778	3383	3353	3386	3686

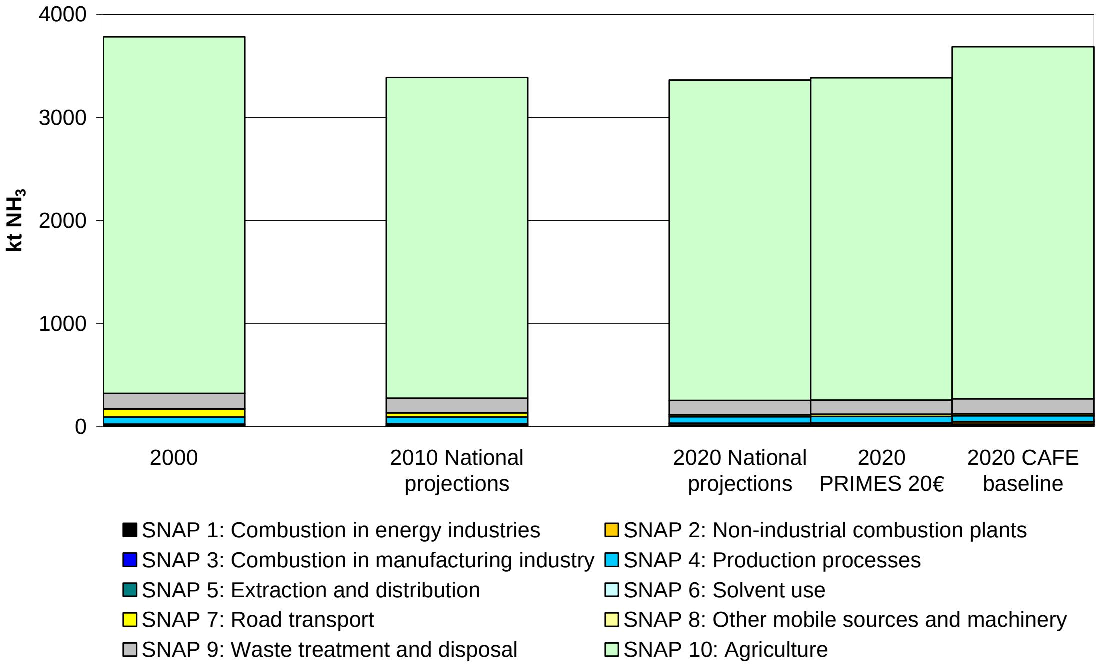

Figure 4.7: NH_3 emissions of the EU-25 by SNAP sector

4.5 Emission projections for volatile organic compounds (VOC)

All three baseline projections of anthropogenic activities indicate a clear decline in VOC emissions between 2000 and 2020, with rather small differences between the results of the different projections; reductions vary between 42 and 44 percent (The largest reductions occur in the emissions from mobile sources.

Table 4.8). The largest reductions occur in the emissions from mobile sources.

Table 4.8: VOC emissions [kt VOC/year]

	2000	*2010*	*2010*	*Projection for 2020*		
		National energy projections	Emission ceiling	National energy projections	PRIMES €20 scenario	CAFE baseline
Austria	180	134	159	119	118	138
Belgium	225	138	139	129	126	144
Cyprus	13	6	14	5	5	6
Czech Rep.	245	208	220	156	145	119
Denmark	140	93	85	72	65	58
Estonia	39	27	49	19	22	17
Finland	149	102	130	82	81	97
France	1579	941	1050	886	985	923
Germany	1323	877	995	661	709	809
Greece	292	159	261	127	127	144
Hungary	173	135	137	123	112	90
Ireland	92	79	55	75	66	46
Italy	1491	844	1159	676	657	731
Latvia	69	58	136	43	40	28
Lithuania	73	55	92	44	44	43
Luxembourg	13	8	9	7	7	8
Malta	7	4	12	4	3	2
Netherlands	259	159	185	168	162	203
Poland	601	439	800	352	429	320
Portugal	270	175	180	157	151	162
Slovakia	103	78	140	76	68	64
Slovenia	53	35	40	30	27	20
Spain	1102	785	662	690	689	692
Sweden	241	166	241	136	145	174
UK	1385	936	1200	862	852	878
EU-25	10120	6640	8150	5699	5835	5916
Bulgaria	138	139		93	93	
Croatia	103	106				
Romania	406	397		288	288	
Turkey	784	664		474	474	
Norway	383	118		71	71	
Switzerland	161	106		90	90	

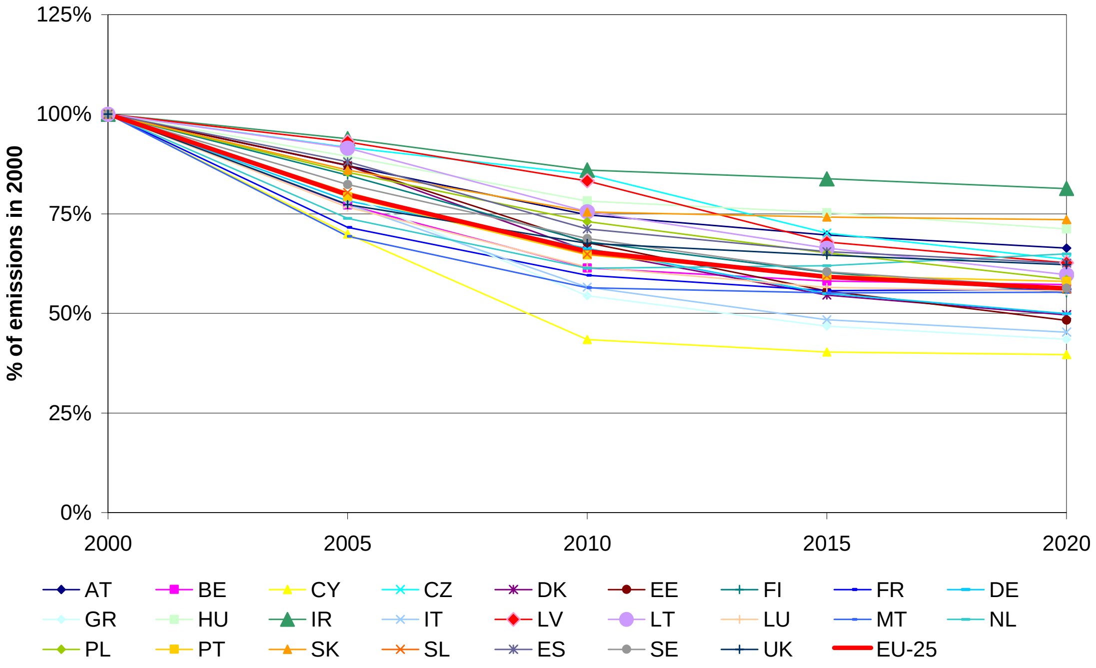

Figure 4.8: VOC emissions resulting from the national activity projections of the EU-25 Member States

Table 4.9: VOC emissions of the EU-25 by SNAP sector [in kt]

	2000	*2010*		*2020*	
		National energy projections	National energy projections	PRIMES €20 scenario	CAFE baseline
SNAP 1: Combustion in energy industries	100	110	100	121	79
SNAP 2: Non-industrial combustion plants	770	611	486	585	531
SNAP 3: Combustion in manufacturing industry	51	68	73	47	41
SNAP 4: Production processes	1079	1034	1036	1056	1070
SNAP 5: Extraction and distribution	713	552	531	577	567
SNAP 6: Solvent use	3542	2626	2360	2361	2409
SNAP 7: Road transport	2933	880	559	557	691
SNAP 8: Other mobile sources and machinery	733	570	365	342	345
SNAP 9: Waste treatment and disposal	111	111	111	111	126
SNAP 10: Agriculture	88	78	78	78	56
Total	10120	6640	5699	5835	5916

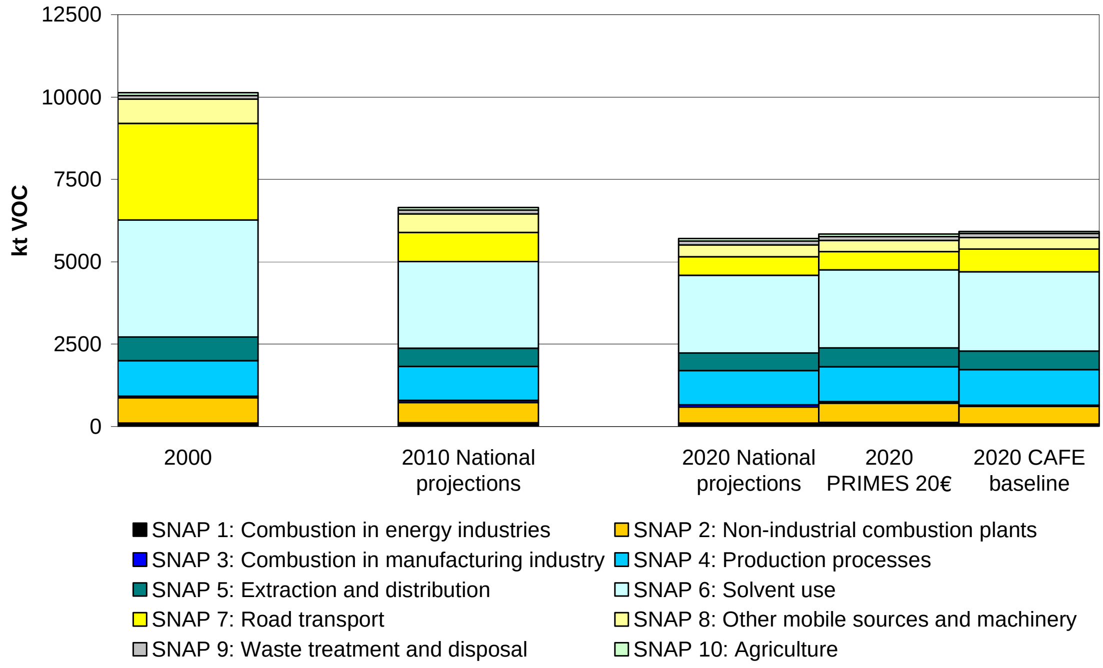

Figure 4.9: VOC emissions of the EU-25 by SNAP sector

4.6 Emission projections for fine particulate matter (PM2.5)

While there are no national emission ceilings for particulate matter in 2010, structural changes in the energy consumption patterns as well as source-specific emission control legislation for large stationary and for mobile sources will reduce PM2.5 emissions in the future. For the EU-25 as a whole, total emissions in the baseline case are computed to decline by 36 to 38 percent in 2020, depending on the volume of coal consumption (Table 4.10). Major contributions to these reductions are made through the ongoing replacement of solid fuels for home heating and for electricity generation, pollution control equipment in the power sector, and emission control measures for mobile sources (Table 4.11).

Table 4.10: Primary PM2.5 emissions [kt PM2.5/year]

	2000	*2010*	*2010*	*Projection for 2020*		
		National energy projections	Emission ceiling	National energy projections	PRIMES €20 scenario	CAFE baseline
Austria	31	25		21	21	27
Belgium	36	29		26	22	24
Cyprus	2	2		2	2	2
Czech Rep.	63	55		38	32	18
Denmark	25	20		15	14	13
Estonia	22	22		20	12	6
Finland	28	25		23	24	27
France	236	169		138	179	165
Germany	159	114		99	102	111
Greece	49	38		30	30	41
Hungary	59	38		42	32	22
Ireland	16	12		9	7	9
Italy	161	137		113	99	99
Latvia	18	17		16	12	4
Lithuania	12	11		10	10	12
Luxembourg	3	2		2	2	2
Malta	1	0		0	0	0
Netherlands	28	21		18	19	26
Poland	197	173		143	138	102
Portugal	81	52		43	37	37
Slovakia	27	22		23	16	14
Slovenia	11	10		9	7	6
Spain	151	108		86	82	90
Sweden	23	19		16	16	39
UK	122	80		61	62	67
EU-25	1561	1199		1003	976	964
Bulgaria	61	62		42	42	
Croatia	21	17		16	16	
Romania	127	142		141	141	
Turkey	313	248		288	288	
Norway	58	52		44	44	
Switzerland	9	8		6	6	

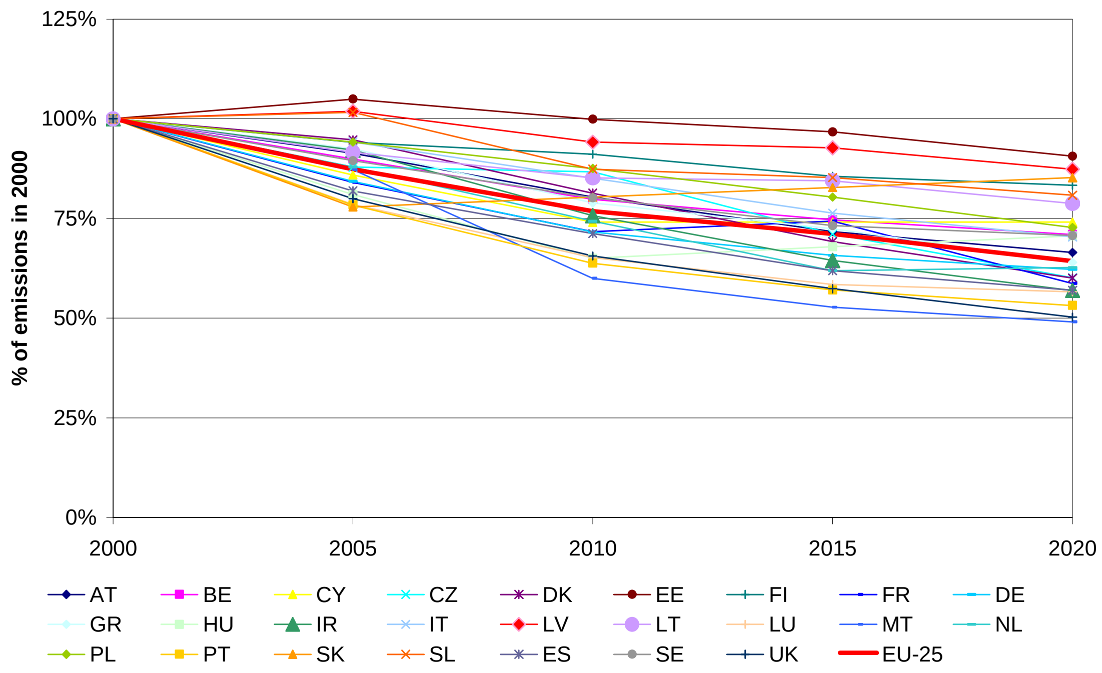

Figure 4.10: PM2.5 emissions resulting from the national activity projections of the EU-25 Member States

Table 4.11: PM2.5 emissions of the EU-25 by SNAP sector [in kt]

	2000	*2010*	*2020*		
		National energy projections	National energy projections	PRIMES €20 scenario	CAFE baseline
SNAP 1: Combustion in energy industries	140	112	107	73	61
SNAP 2: Non-industrial combustion plants	453	376	310	320	319
SNAP 3: Combustion in manufacturing industry	130	101	104	107	90
SNAP 4: Production processes	202	160	165	162	157
SNAP 5: Extraction and distribution	7	5	4	4	4
SNAP 6: Solvent use	0	0	0	0	0
SNAP 7: Road transport	315	176	96	91	121
SNAP 8: Other mobile sources and machinery	152	114	62	61	73
SNAP 9: Waste treatment and disposal	80	79	79	80	79
SNAP 10: Agriculture	81	76	77	78	61
Total	1560	1198	1003	976	964

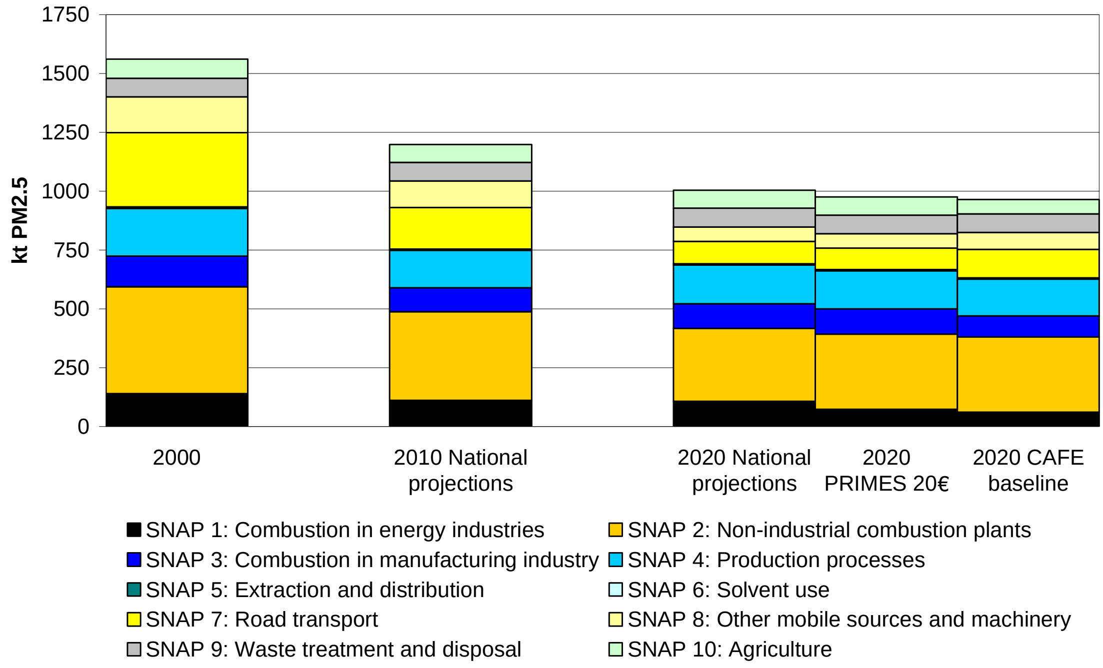

Figure 4.11: PM2.5 emissions of the EU-25 by SNAP sector

4.7 Emissions from international shipping

In addition to the emissions that are included in national inventories (i.e., emissions from land-based sources and national (inland and coastal) shipping, also emissions from international shipping activities influence air quality in Europe. A study is currently carried out that estimates emissions from these sources for the year 2000 (including their spatial distribution and distinguishing several categories of ships) as well as the future development of emissions under different policy assumptions. However, at time of writing this report, this study is not yet finalized. Therefore, in order to facilitate a first comprehensive assessment of future air quality in Europe, Table 4.12 presents preliminary projections of emissions from these sources. This table presents baseline emissions, i.e., emissions as they are expected under current emission control legislation. In particular, these projections assume for SO_2 the requirements of the marine fuel sulphur directive:

- 0.1 percent sulphur content for marine diesel oil;
- 1.5 percent sulphur content for residual marine fuel oil in the "sulphur emissions control areas", i.e., the Baltic Sea and the North Sea;
- 1.5 percent sulphur content for all passenger ships in other EU seas;
- 0.1 % percent sulphur content for fuel used at berth.

For NO_x emissions, the projection assumes implementation of the MARPOL NO_x emission standards for all ships built since 2000.

Table 4.12: Emissions from international shipping for 2000 and 2020 under baseline assumptions (kt), preliminary estimates

	2000			*2020*		
	SO_2	NO_x	PM2.5	SO_2	NO_x	PM2.5
Baltic Sea	196	277	18	166	407	25
Black Sea	59	82	6	96	120	9
Atlantic Ocean (area included in the EMEP domain)	494	728	51	799	1065	84
Mediterranean Sea	1093	1574	109	1737	2349	178
North Sea	463	652	45	394	961	61
Total	2306	3313	229	3192	4903	357

5 Health and environmental impacts

This section provides a preliminary assessment of the health and environmental impacts of the baseline emissions projected for the various scenarios for the year 2020. Due to time constraints in producing this report before the Conference on Air Pollution and Greenhouse Gas Emission Projections for 2020, this assessment relies on approximations conducted with the reduced-form functional relationships of the RAINS model, while the full impact assessment is usually carried out based on calculations with the comprehensive EMEP Eulerian atmospheric transport model for the emissions of a particular scenario. Thus, the quantitative results presented in this report have to be considered as indicative to allow a timely assessment of air quality impacts for the Conference. **However, they should not be directly compared with quantitative estimates of the environmental impacts presented in the reports of the CAFE programme without considering the methodological differences.** A full assessment of the environmental impacts of the baseline scenarios will be presented together with the first policy analysis scenarios in December 2007.

One of the shortcomings of this preliminary assessment relates to the quantification of impacts for countries outside the EU-25, which could only partially be completed due to lack of data.

Among other modifications, the assessment of ecosystems protection against acidification and eutrophication presented in this report employs the most recent database on critical loads as approved by the UNECE Working Group on Effects in August 2006, while the CAFE assessment relied on the 2004 version of this database.

Further methodological improvements are underway to be completed before the final impact assessment in the course of the policy scenario analyses at the end of 2006. These will include:

- an improved methodology to estimate urban pollution levels, based on the outcomes of the City-Delta III project,
- the consideration of the inter-annual meteorological variability through the analysis of the meteorological conditions of five different years,
- updated estimates of the projected pollution levels in the non-EU countries and their impacts on background levels in the EU,
- an improved representation of the formation of ground-level ozone,
- revised assumptions on the likely development of hemispheric ozone background levels,
- revised projections of emissions from marine activities,
- updated projections of the emissions on the non-EU countries and their impacts on background air quality in the EU-25.

5.1 Health impacts of fine particulate matter

The preliminary analysis of health impacts of fine particulate matter indicates for the national energy projections – for the EU-25 as a whole – a loss in statistical life expectancy attributable to PM2.5 similar to the impacts of the CAFE baseline scenario (5.5 months in 2020), compared to 7.7 months in 2000 (Table 5.1). While the new estimate for the base year is somewhat lower than in the CAFE analysis due to modifications in the emission inventories of PM2.5, the impacts estimated for 2020 remain constant despite significantly higher emissions of energy-related air pollutants (SO_2, NO_x and PM2.5) than resulting from the CAFE baseline projection. This is caused by the lower projection of agricultural ammonia emissions, mainly due to the impacts of the mid-term review of the CAP reform.

Table 5.1: Preliminary estimates of loss in statistical life expectance attributable to the human exposure to fine particulate matter (PM2.5) originating from anthropogenic emission sources (months)

	2000		*2020*	
		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	6.7	5.0	4.7	5.0
Belgium	12.9	9.2	8.8	9.3
Cyprus	4.4	4.1	4.1	4.2
Czech Rep.	8.9	6.4	6.1	5.8
Denmark	5.7	4.3	4.2	4.6
Estonia	3.6	3.2	2.8	2.9
Finland	2.3	2.1	2.0	2.1
France	7.5	5.4	5.5	5.6
Germany	9.1	6.2	5.9	6.7
Greece	6.1	4.9	4.8	5.0
Hungary	10.7	8.4	7.7	7.6
Ireland	4.0	2.5	2.4	2.7
Italy	7.3	5.6	5.2	5.3
Latvia	4.3	3.8	3.5	3.4
Lithuania	5.4	4.5	4.4	4.6
Luxembourg	9.3	6.4	6.2	6.8
Malta	5.9	5.1	4.9	5.2
Netherlands	11.7	8.4	8.0	8.7
Poland	9.3	7.2	7.1	6.7
Portugal	6.3	3.6	3.3	3.2
Slovakia	9.2	7.0	6.6	6.4
Slovenia	7.7	6.0	5.6	5.7
Spain	4.7	3.0	2.9	3.0
Sweden	2.9	2.4	2.3	2.7
UK	7.0	4.5	4.4	4.8
EU-25	7.7	5.5	5.3	5.5
Bulgaria				
Croatia				
Romania				
Turkey				
Norway				
Switzerland				

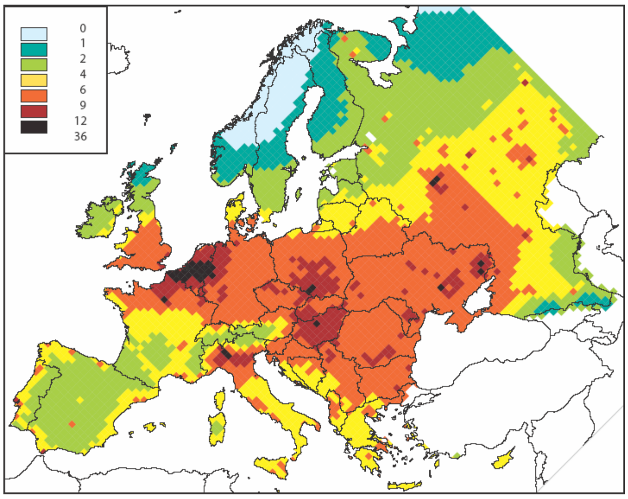

Figure 5.1: Loss in statistical life expectancy attributable to the exposure to PM2.5 from anthropogenic sources for the emissions of the year 2000 (in months)

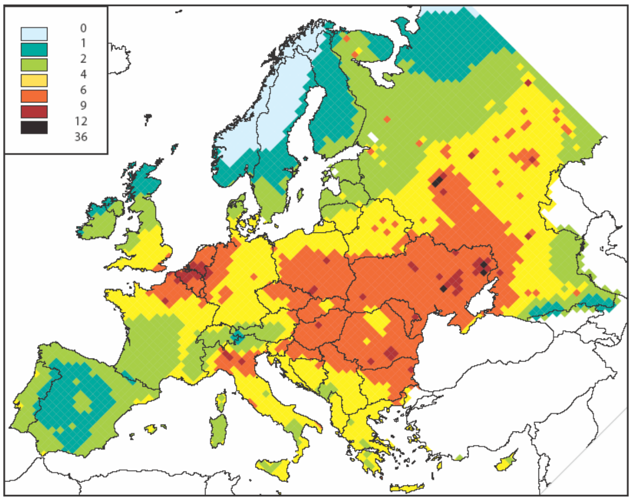

Figure 5.2: Loss in statistical life expectancy attributable to the exposure to PM2.5 from anthropogenic sources for the emissions of the national energy projections for the year 2020 (in months)

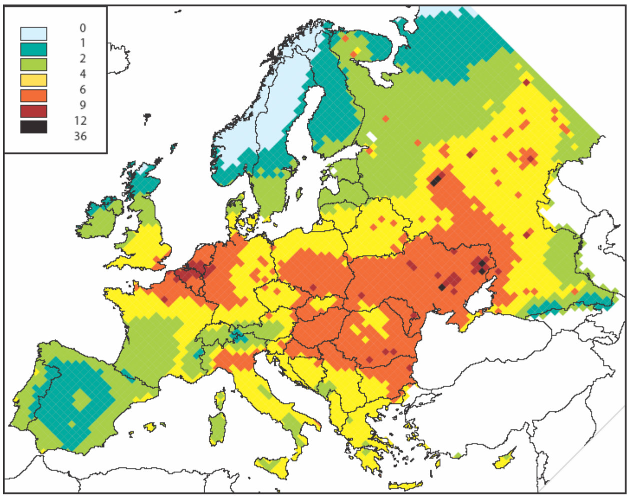

Figure 5.3: Loss in statistical life expectancy attributable to the exposure to PM2.5 from anthropogenic sources for CAFE baseline scenario for 2020 (in months)

5.2 Premature mortality attributable to ground-level ozone

Due to time constraints in producing this report, only a very preliminary analysis with numerous assumptions could be conducted for the health impacts of ground-level ozone. While all quantitative conclusions from the applied methodology must be interpreted with extreme caution, somewhat meaningful findings can only be drawn from a comparison of the impact estimates for the year 2020. This limitation is caused, inter alia, by the nature of the applied ozone formation model that is only designed for changes in emissions in a narrow range around the levels that are likely for the year 2020. Furthermore, the available coefficients of this model have been developed for an earlier (lower) assumption on the development of hemispheric background ozone, and they do not reflect latest information on the development of emissions from ships and from the non-EU countries. Furthermore, due to important non-linearities in ozone formation the full assessment, which will be produced for the follow-up policy scenario analysis, could change this estimate result significantly.

With this caveats, the indicative assessment suggests slightly higher numbers of premature deaths attributable to ozone. Compared to the CAFE baseline scenario the increase ranges between five and nine percent, depending on the energy projection, and is mainly related to higher NO_x emissions.

Table 5.2: Preliminary estimates of the number of cases of premature deaths attributable to the human exposure to ground-level ozone. In particular, the estimate for the year 2000 reflects a zero-order approximation only (see note below). These numbers should not be used for drawing robust conclusions.

	2000)*	*2020*		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria		366	343	327
Belgium		433	418	416
Cyprus		24	23	24
Czech Rep.		475	448	397
Denmark		173	167	162
Estonia		20	19	18
Finland		56	54	52
France		2481	2334	2302
Germany		3945	3813	3580
Greece		496	488	479
Hungary		606	576	524
Ireland		83	79	80
Italy		3796	3621	3493
Latvia		55	52	50
Lithuania		51	50	47
Luxembourg		30	29	28
Malta		20	19	18
Netherlands		473	456	455
Poland		1130	1114	997
Portugal		475	461	443
Slovakia		195	185	167
Slovenia		92	84	80
Spain		1929	1875	1720
Sweden		186	181	176
UK		1901	1860	1854
EU-25		19490	18750	17888
Bulgaria				
Croatia				
Romania				
Turkey				
Norway				
Switzerland				

*) No robust assessment available at this time.

5.3 Protection of ecosystems against acidification

Furthermore, initial estimates are available for the protection of ecosystems against acidification and eutrophication. Since, at time of writing this report, the revised estimate for the CAFE baseline projection is not completed, no comparisons to earlier estimates can be drawn in this background paper.

5.3.1 Forests

Table 5.3: Preliminary estimates of forest area with acid deposition above critical loads for acidification

	Forest area with acid deposition above critical loads for acidification [km²]				*Percent of forest area with acid deposition above critical loads for acidification*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	372	0	0		1%	0%	0%	
Belgium	4797	1600	1082		76%	25%	17%	
Cyprus	0	0	0		0%	0%	0%	
Czech Rep.	8875	4363	2867		79%	39%	26%	
Denmark	1176	171	90		37%	5%	3%	
Estonia	0	0	0		0%	0%	0%	
Finland	3534	1947	1563		2%	1%	1%	
France	17032	10888	8857		10%	6%	5%	
Germany	62743	29418	20726		62%	29%	21%	
Greece	960	260	257		10%	3%	3%	
Hungary	50	0	0		1%	0%	0%	
Ireland	2012	788	680		47%	19%	16%	
Italy	0	0	0		0%	0%	0%	
Latvia	354	0	0		1%	0%	0%	
Lithuania	12797	8792	8389		73%	50%	48%	
Luxembourg	272	170	167		33%	21%	20%	
Malta								
Netherlands	5116	5014	4927		91%	89%	87%	
Poland	50820	16554	15352		58%	19%	17%	
Portugal	4304	1046	1042		20%	5%	5%	
Slovakia	4602	1748	1569		24%	9%	8%	
Slovenia	666	2	2		13%	0%	0%	
Spain	946	77	51		1%	0%	0%	
Sweden	40097	11331	8538		18%	5%	4%	
UK	11122	4341	3805		56%	22%	19%	
EU-25	232647	98554	79992		19%	8%	7%	
Bulgaria	0	0	0		0%	0%	0%	
Croatia	652	0	0		9%	0%	0%	
Romania	3316	144	100		5%	0%	0%	
Turkey								
Norway	1769	375	248		3%	1%	0%	
Switzerland	1748	656	701		15%	6%	6%	

5.3.2 Semi-natural vegetation

Table 5.4: Preliminary estimates of semi-natural ecosystems with acid deposition above critical loads for acidification

	Area with semi-natural ecosystems with acid deposition above critical loads for acidification [km²]				*Percent of area with semi-natural ecosystems with acid deposition above critical loads for acidification*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Belgium	433	182	112		59%	25%	15%	
Cyprus	0	0	0		0%	0%	0%	
France	3371	2665	2507		36%	28%	27%	
Germany	714	231	97		22%	7%	3%	
Ireland	403	4	3		9%	0%	0%	
Italy	0	0	0		0%	0%	0%	
Netherlands	1094	985	904		64%	58%	53%	
UK	16865	4031	3519		34%	8%	7%	
EU-25	22886	8100	7139		21%	8%	7%	

5.3.3 Freshwater ecosystems

Table 5.5: Preliminary estimates of freshwater ecosystems with acid deposition above critical loads

	Catchment area of freshwater ecosystems with acid deposition above critical loads for acidification [km²]				*Percent of Catchment area of freshwater ecosystems with acid deposition above critical loads for acidification*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Finland	29	13	11		0%	0%	0%	
Italy	0	0	0		0%	0%	0%	
Sweden	28114	18056	16380		10%	6%	6%	
UK	674	268	225		9%	3%	3%	
EU-25	28825	18352	16612		9%	6%	5%	
Norway	58470	36886	34180		18%	11%	11%	
Switzerland	122	74	67		74%	45%	41%	

5.4 Protection of ecosystems against eutrophication

5.4.1 Forests

Table 5.6: Preliminary estimates of forest area with nitrogen deposition above critical loads for eutrophication

	Forest area with nitrogen deposition above critical loads for eutrophication [km²]				*Percent of forest area with nitrogen deposition above critical loads for eutrophication*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	35184	26455	24268		98%	74%	68%	
Belgium	6306	6171	6141		100%	98%	97%	
Cyprus	1526	1521	1521		66%	66%	66%	
Czech Rep.	11163	10788	10755		100%	97%	96%	
Denmark	3010	2582	2548		96%	82%	81%	
Estonia	9155	3934	2252		43%	18%	11%	
Finland	80992	35748	36806		34%	15%	15%	
France	169343	160350	158575		99%	94%	93%	
Germany	99965	95200	94321		99%	94%	93%	
Greece	9326	9326	9326		100%	100%	100%	
Hungary	10262	6882	5870		98%	66%	56%	
Ireland	4081	3793	3786		96%	89%	89%	
Italy	77693	62459	55653		87%	70%	62%	
Latvia	25847	25617	25104		96%	95%	93%	
Lithuania	17651	17651	17651		100%	100%	100%	
Luxembourg	821	821	821		100%	100%	100%	
Malta					0%	0%	0%	
Netherlands	2645	2577	2559		99%	96%	96%	
Poland	86439	82992	83381		98%	94%	94%	
Portugal	20159	20030	19578		95%	94%	92%	
Slovakia	19230	17026	16331		100%	88%	85%	
Slovenia	5264	5246	5240		100%	100%	100%	
Spain	77597	68674	67123		91%	81%	79%	
Sweden	40840	18111	17300		18%	8%	8%	
UK	18392	14671	14383		92%	74%	72%	
EU-25	832916	698645	681344		68%	57%	56%	
Bulgaria	45764	40037	39360		95%	83%	81%	
Croatia	3469	2801	2766		50%	40%	40%	
Romania	60546	59648	59635		96%	95%	95%	
Turkey					0%	0%	0%	
Norway					0%	0%	0%	
Switzerland	9273	6726	6991		94%	68%	71%	

5.4.2 Semi-natural ecosystems

Table 5.7: Preliminary estimates of semi-natural ecosystems with nitrogen deposition above critical loads for eutrophication

	Area with semi-natural ecosystems with nitrogen deposition above critical loads for eutrophication [km²]				*Percent of area with semi-natural ecosystems with nitrogen deposition above critical loads for eutrophication*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Belgium	421	269	267		57%	36%	36%	
Cyprus	1556	1564	1560		89%	90%	90%	
France	7332	6939	6855		78%	74%	73%	
Germany	1696	1093	1079		52%	34%	33%	
Ireland	3890	2862	2945		83%	61%	63%	
Italy	10796	9339	8344		30%	26%	23%	
Netherlands	1442	1247	1221		84%	73%	71%	
UK	4394	462	483		8%	1%	1%	
EU-25	31656	23771	22752		28%	21%	20%	
Norway	10806	4271	4271		3%	1%	1%	
Switzerland	7000	4096	3480		55%	32%	27%	

5.4.3 Freshwater ecosystems

Table 5.8: Preliminary estimates of freshwater ecosystems with nitrogen deposition above critical loads for eutrophication

	Catchment area of freshwater ecosystems with nitrogen deposition above critical loads for eutrophication [km²]				*Percent of catchment area of freshwater ecosystems with nitrogen deposition above critical loads for eutrophication*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Italy	10796	9339	8344		30%	26%	23%	
Netherlands	10796	9339	8344		30%	26%	23%	
EU-25	10796	9339	8344		30%	26%	23%	
Switzerland	10796	9339	8344		30%	26%	23%	

5.4.4 All ecosystems

Table 5.9: Preliminary estimates of total ecosystems area with nitrogen deposition above critical loads for eutrophication

	Total ecosystems area with nitrogen deposition above critical loads for eutrophication [km²]				*Percent of total ecosystems area with nitrogen deposition above critical loads for eutrophication*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	35184	26455	24268		98%	74%	68%	
Belgium	6727	6440	6409		95%	91%	91%	
Cyprus	3082	3085	3081		76%	76%	76%	
Czech Rep.	11163	10788	10755		100%	97%	96%	
Denmark	3010	2582	2548		96%	82%	81%	
Estonia	9280	3933	2252		41%	18%	10%	
Finland	80992	35748	36806		34%	15%	15%	
France	176680	167296	165423		98%	93%	92%	
Germany	101663	96297	95401		98%	92%	92%	
Greece	9326	9326	9326		100%	100%	100%	
Hungary	10262	6882	5870		98%	66%	56%	
Ireland	7970	6655	6731		89%	75%	75%	
Italy	88492	71801	63996		70%	57%	51%	
Latvia	25847	25617	25104		96%	95%	93%	
Lithuania	17651	17651	17651		100%	100%	100%	
Luxembourg	821	821	821		100%	100%	100%	
Malta								
Netherlands	4092	3830	3786		93%	87%	86%	
Poland	86439	82992	83381		98%	94%	94%	
Portugal	20159	20030	19578		95%	94%	92%	
Slovakia	19230	17026	16331		100%	88%	85%	
Slovenia	5264	5246	5240		100%	100%	100%	
Spain	77597	68674	67123		91%	81%	79%	
Sweden	40840	18111	17300		18%	8%	8%	
UK	22788	15138	14863		31%	20%	20%	
EU-25	864593	722381	704005		65%	54%	53%	
Bulgaria	45764	40037	39360		95%	83%	81%	
Croatia	3469	2801	2766		50%	40%	40%	
Romania	60546	59648	59635		96%	95%	95%	
Turkey								
Norway	10806	4271	4271		3%	1%	1%	
Switzerland	16320	10871	10520		72%	48%	46%	

6 Conclusion

As a preparation for the revision of the National Emission Ceilings Directive, this report revisits the baseline projections on future European emissions and air quality that have been produced for the CAFE (Clean Air For Europe) programme for the European Union. It examines the implications of updated information on how Member States see the future development of their energy and agricultural systems, and which factors and assumptions have largest impacts on the projections of future emissions.

In 2004, the baseline analysis of the CAFE programme developed the following main conclusions:

- Emissions of air pollutants will further decline in the EU in the coming two decades. This is a consequence of progressing implementation of already decided emission control legislation, and of ongoing structural changes in the energy system. Largest declines are foreseen for energy related emissions, especially for SO_2, NO_x, VOC and primary PM2.5, while for emissions from agricultural activities lower declines are anticipated.
- Despite the projected decline in emissions, poor air quality will remain a threat to European population. Especially the exposure to fine particulate matter will result in significant shortening of statistical life expectancy.
- Also for vegetation, emissions will not decline sufficiently to safeguard sustainable conditions for the European forests, semi-natural ecosystems (e.g., nature protection areas) and freshwater bodies. While acidification will decline substantially, eutrophication from excess nitrogen deposition will remain a wide-spread threat throughout Europe.
- The relevance of emission sources will change due to legislation imposed on the currently largest contributors. Traditional “large polluters” will reduce their contributions and other sources will take over. Depending on the pollutant of concern, ships, industrial processes, small combustion sources, off-road machinery and agriculture will emerge as the main sources.
- Emissions from marine shipping will surpass emissions from land-based sources in the EU.
- The development in the energy and agricultural sectors are a main determinant for future emissions of air pollutants.

These conclusions also hold from the refined analysis conducted for the revision of the NEC Directive. The additional information on alternative projections of energy and agricultural activities collected for this analysis reinforces especially the last finding about the sensitivity of emission projections against the assumptions on future anthropogenic driving forces. Modified assumptions on agricultural trends and policies yield two times larger reductions of ammonia emissions than foreseen in the CAFE analysis. Conversely, different perspectives on the development of the energy sector result in up to 40 percent higher baseline emissions of SO_2, NO_x and PM2.5. The analysis reveals a particular strong association between assumptions on climate policy and air pollutant emissions, but indicates emission projections to be more robust against different assumptions about future oil prices or other energy policy issues.

The compilation of national energy projections discloses substantial differences to the CAFE baseline energy projection that has been developed in 2004 with the PRIMES energy model. National perspectives envisage significantly higher use of coal and diesel than the Europe-wide scenario. Most importantly, collectively for the EU-25 these national projections result in 2020 in a two percent increase in CO_2 emissions compared to the base year emissions of the Kyoto protocol.

Coherence between different policy areas is also an issue for the national projections in relation to the current Emission Ceilings Directive with 2010 as a target year. Taking into consideration the current national legislation communicated to IIASA by the national experts, emission projections for 2010 exceed for some Member States the national emission ceilings by a considerable margin. Largest discrepancies occur for NO_x, where the projected emissions of 11 out of 25 Member States exceed the national ceilings by more than 25 percent. Furthermore, for several Member States their national energy projections imply increasing emissions after the year 2010.

All issues outlined above, i.e., the dominant influence of assumptions on climate policy, the effectiveness of the implementation of the recent changes in agricultural policies, and the coherence with other policy fields will be critical elements in the forthcoming development of proposals for revised national emission ceilings.

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